Lower Suncook Lake
2, 4 –D Research Program

Project Final Report

Submitted by:
Suncook Lake Association
Milfoil Control Committee
S. Edward Neister - Chairman

October 31, 2004

Project Manager: ______________________________
Signature / Date
S. Edward Neister, Milfoil Control Committee

Project Quality Assurance Officer: ______________________________
Signature / Date
Ron Weston, Milfoil Control Committee

Program Quality Assurance Coordinator: ______________________________
Signature / Date
Andy Chapman, NH-DES, Watershed Management Bureau

DES Project Manager: ______________________________
Signature / Date
Amy Smagula, NH-DES, Watershed Management Bureau

CFB Task Manager ______________________________
Signature / Date
Jeffery Schloss, Center for Freshwater Biology, UNH

ERG Task Manager: ______________________________
Signature / Date
Dr. James Malley, Environmental Research Group, UNH

Document control number: ____________

Table of Contents

Table of Contents 2
Summary: 3
Purpose/goals: 3
Project Results: 4
1. Treatment: 4
2. 2, 4-D Tracking: 7
3. 2, 4-D Destruction: 11
Legislative Action: 12
Lake Treatment Program: 15
SURVEY: 15
TREAT: 16
OBSERVE: 17
PULL: 17
MONITOR: 18
Appendix A – Report Pictures: 19
Appendix B – Water Sample Data: 29
Appendix C – ERG Report: 35
Batch, Bench-Scale Treatment of 2,4-D Contaminated Well Water 35
Research Approach 35
Research Results For UV Alone 36
Research Results For UV-Peroxide 36
Research Results - GAC Adsorption 37
Research Results – GAC Adsorption Table 37
Research Results – GAC Adsorption Equation 38
Quality Assurance 38
Summary 39
Appendix D: ACT Final Report 40
Treatment Summary 40
Results 41

Summary:

This final report by the Suncook Lake Association (SLA) in Barnstead New Hampshire describes their approach and results of treatment for variable milfoil in Lower Suncook Lake during the summer of 2004. Initial results indicate their approach, with appropriate monitoring and follow up, may lead to the eradication of milfoil from their lake. This report also includes the study of herbicide movement in the lake after treatment, its potential to contaminate wells, and the study of mechanisms that significantly reduce herbicide concentration.

SLA organized a milfoil control committee (MCC) to inform all property owners of the program, to obtain a complete listing of all water supplies near the shore, apply for a State funded research grant, hold public hearings to answer any questions, and obtain abutter and town support. The MCC formed a diving group that would survey the lake prior to treatment, observe the effects of the treatment, locate and remove any surviving plants.

A significant part of the program was the use of many volunteers to complete the tasks required throughout the program. The combined estimate was $80,000 of donated time and resources in a $150,000 program. Tasks included; survey all property owners to locate all domestic well and water sources, inform everyone of public meetings, send out certified mailings and informational and legal notices, tow volunteer divers around the lake to complete the lake survey prior and post treatment, and assist the divers in the removal of plants that survived the treatment. A unique articulated tow able sled was developed to facilitate examination of the lake bottom by divers (Signaling Scuba Tow/SST).

The approach was to develop a plan that could lead to the permanent eradication of milfoil from the lake. The plan used the latest technology to locate all milfoil plants in the lake and resources from UNH to study of herbicide movement in the lake; it's potential to contaminate wells close to shore and potential methods that could be used to reduce herbicide concentrations in wells. UNH also performed a drogue study on the lake current prior to treatment and made video recordings of the milfoil and lake bottom condition prior and following treatment.

Results are very encouraging. All milfoil appears to have been removed by either the herbicide treatment or by diver removal. Herbicide was not found in any wells. A model was tested to show the very low possibility for herbicide to contaminate nearby shallow wells. 2, 4 -D appears to be very sensitive to techniques that cause its destruction in both lake outflow streams and treatment streams. Video accurately recorded milfoil destruction and the revival of the lake bottom during the program. Total milfoil eradication from the lake will not be known until after examining the lake for any re-growth during the summer of 2005.

Purpose/goals:

The amount of milfoil in the lake covered 44% of the Lower Suncook Lake. Milfoil was found in about 95% of areas that would support milfoil growth. It covered 132 acres with mature plants at separations of 5-15 feet. In order to manage and control milfoil in the lake, it first had to be reduced in size and coverage that would make future dive management possible.

The purpose was two fold. First was to reduce the amount of milfoil in the lake to a level so that local divers can manage any further spread. This could only be done effectively by the use of 2, 4-D herbicide treatment. The 'Lake Host' program along with constant vigilance by lake inhabitants and property owners will contribute to the overall future management process.

Second was to do a significant research study of 2, 4-D treatment in a NH lake for the purpose of gaining a better understanding of the herbicide treatment. The study would record the treatment response, its half-life, any local well contamination and methods that could be used to remove contamination from wells if it occurs.

The goals of the program were to provide knowledge of effectiveness of treatment in each area of the lake that has different conditions of water, wind, depth, current, and milfoil concentration. A diver program was to report on the herbicide's effectiveness, and the success of follow up management techniques. The impact on native plants, mussels, and fish would also be observed.

The knowledge gained in this program is to be used to promote better laws and more appropriate permit restrictions so that milfoil management in New Hampshire and in the NE Region can become more effective. This should result in a reduction of coverage of milfoil in the area's lakes, better management procedures and for the first time a reclaiming of the water ways that have been lost to milfoil infestation.

Project Results:

This report includes appropriate charts with the discussion. The complete data set and charts are included in the appendix for completeness.

1. Treatment:

Preparation:

The result of the previous year's survey (Figure 1) was used to determine the application treatment area and the estimate for the amount of herbicide to use. The treatment area was estimated to be 140 acres after compiling all of the diver reports for Lower Suncook Lake. The permit application was made using this amount. Prior to the treatment in 2004, divers re-surveyed the lake looking for new growth and any changes in the estimate. An additional 10 acres were found in the North West part of the lake. However, by using a depth gauge on the boat, the re-survey established areas in the treatment zones that did not have milfoil due to bottom depths greater than 12 feet.

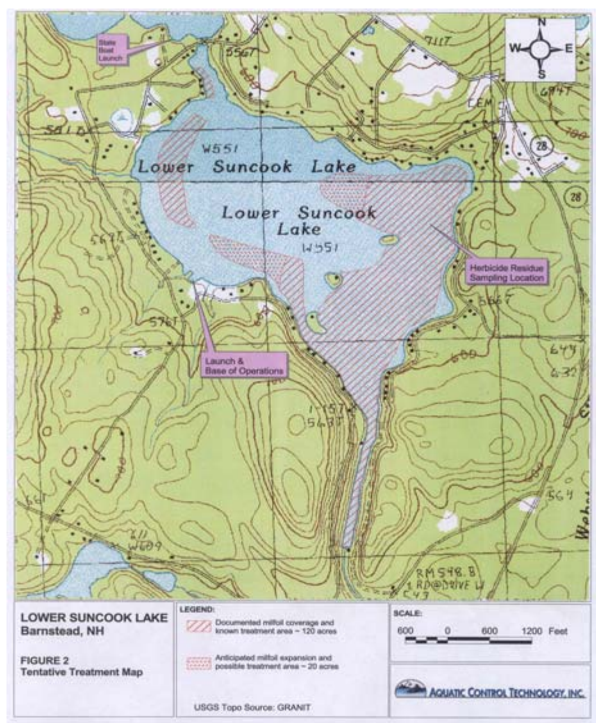


Figure 1: 2003 Survey

These areas amounted to about 12 acres. With the new data (Figure 2), the final treatment zones were drawn and measured using the DeLorme TOPO 5.0 topographical mapping program and the Earthmate GPS receiver attached to a laptop USB port. Its use is described in detail in the 'Lake Treatment Program' section. Using the aerial view of the Lower Lake, 300 acres were measured for the lake size.

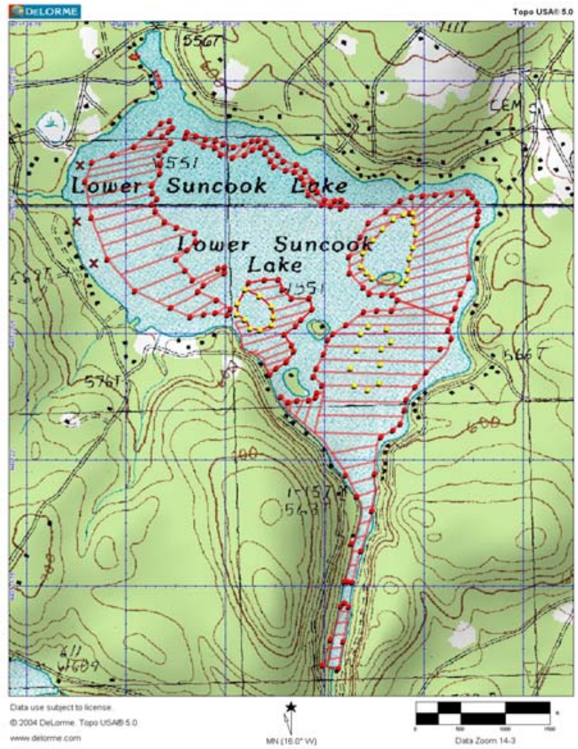


Figure 2: 2004 Survey

Critical to the success of the treatment was the ability to place the pellets on top of the area occupied by the milfoil plants. Spreading the herbicide pellets by boat makes the application uniform only at the surface of the water. Currents that exist at different levels in the lake caused by water flowing through the lake or driven by wind can affect the descent of the pellets so that they do not map to the intended location on the lake bottom.

In order to maximize the chance for proper coverage, only applicator boats were permitted on the lake the day of treatment. The treatment day was chosen for the least amount of wind. The dam that controls the water outflow from the lake was raised by 4 inches to help stop the lake currents.

A drogue study prior to application verified that the most significant currents that existed in the lake were driven by the existing wind. It also disclosed that a counter-current was generated in the deeper waters opposite to the wind direction. Two applicator days were chosen in order to be able to choose the best day that had the least wind for the treatment date.

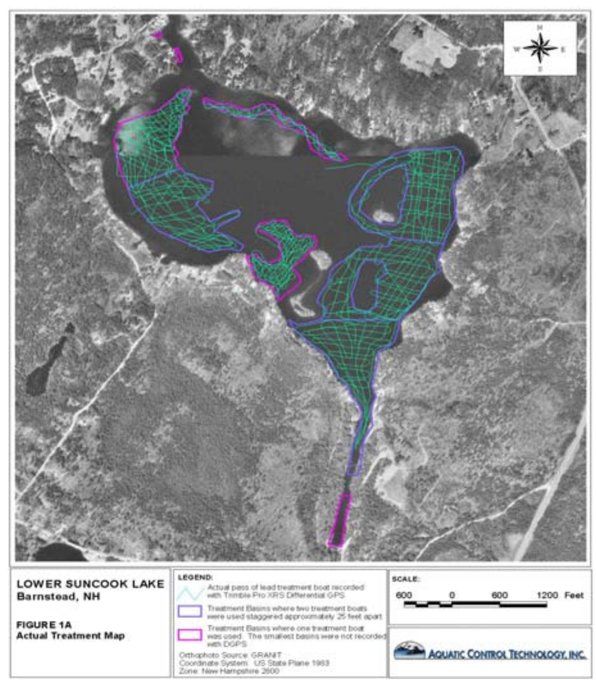


Figure 3: Aquatic Control Treatment

Application:

Before treatment started, the herbicide applicator boat was used to survey areas close to shore that were too shallow or had obstacles that prevented a diver survey. This survey found three patches of milfoil that were added to the treatment zones. The final treatment area was 132 acres, or 44% of the 300 acre lake. The application was done in one 11 hour day, taking about 1 hour to treat 10 acres. Pictures in the Appendix show that the treatment day had very little wind, and the lake condition was the best it could be for the application.

Aquatic Control Technology was the applicator of the herbicide. They applied 100 pounds per acre to the lake on June 24, 2004. 'The treatment proceeded smoothly and without incident. The post-treatment inspection was conducted on July 15th. …No viable milfoil plants were found in the treatment areas or in any other portions of Lower Suncook Lake.' Their final report is included in the Appendix. Figure 3 is a record of the GPS controlled treatment on Lower Suncook Lake.

Results:

Prior to the start of the treatment, pictures were taken of milfoil close to the surface in two different parts of the lake. These are also included in the Appendix and are used for comparison with pictures taken after treatment. A six-day comparison (Figure 4) shows a loss of the bright

Figure 4: Pre & 6 day Post Treatment

green color by the plant, a change in the flexibility of the stalk and a distortion in the stalk alignment compared to other stalks near by. Prior to treatment, all the stalks were very flexible, following the prevailing current of the passing water. At six days, distortion of the stalk alignment was very prevalent. The stalks also were beginning to fall back towards the lake bottom. All of the plant branches were lower in the water and began to take on the appearance of the plant starting to lie down on the lake bottom.

A video recording was made post treatment of two specific areas in the lake. The video captures the appearance change of the milfoil, showing bare defoliated stalks by the sixth day, and some defoliated partially decayed stalks still standing by the third week. On the third week, the lake floor is almost barren, populated by short native plants (primarily Vallisneria Americana) spaced far apart. Mussels and small fish are seen to be normal and active. By the 60th day, the lake floor took on a new appearance with significant coverage of new native plant growth in both the shallow (Vallisneria dominated) and deep sections (dominated by Utricularia sp,) of the lake.

Divers began surveying the Lower Lake about 4 weeks after treatment. First, areas that weren't treated were examined using the SST and 1 or two divers. Second, areas that were most likely to contain surviving plants were surveyed. Finally, selected areas in the lake where high-density plants existed prior to treatment were examined.

The only milfoil that was found was by an observer in a kayak near the narrows bridge inlet. The water was too shallow to put divers into the region, and it was upstream of the nearby treatment area by about 100 feet. A diver pulled the plants on the day the observer noticed them. Checking the area showed no further growth. It amounted to about 5 gallons of plant.

The Upper Lake had been examined repeatedly during the 2003 summer season from small boats and canoes with no milfoil findings. However, in mid July, following herbicide treatment of the Lower Lake, divers found a large patch of milfoil while surveying Upper Suncook Lake. No treatment was done in this lake, but it was most important to remove any plants, since they would act as a source for new growth to enter into the Lower Lake. The patch was pulled using multiple divers on two separate days. About 15 gallons of various plant lengths were removed. The area was checked two weeks later, and several new plants were removed. Two more checks were made, each two weeks apart. After the third follow up check, no new plants were found.

2. 2, 4-D Tracking:

The UNH Center for Freshwater Biology (CFB) Analytical Laboratory performed the 2, 4-D analysis. Before the treatment both the CFB project task manager and the lab manager were certified in the ELISA Assay method by Strategic Diagnostics Incorporated of Newark Delaware. All sample analysis runs included a calibration sample set as well as a negative and positive control. The percent coefficient of variation of standard replicates was always below 5% and averaged 2.3%. Matrix spikes yielded 98 to 103 percent recovery. Blind duplicate samples provided by the UNH Environmental Research Group yielded an average Relative Percent Standard Deviation (%RSD) of 3.6%. In-lab replicate % RSD's were always under 0.5 percent.

Figure 5: Lower Suncook Lake

Over 150 water samples were taken of the lake water and test well water from the day prior to treatment to 60 days post treatment. Two areas of the lake (A &B) were used to determine if changes due to lake conditions affected the herbicide residual concentration with time. Water outflow samples were also taken to determine if outflow conditions could affect the residual concentration downstream. A temperature profile was made of both areas in May, on the expected treatment date of June 8, and then on the day after the actual treatment.

Lake Area:

Each of the two water sample positions was chosen for the same depth so that a temperature profile comparison could be made. Each position was marked by GPS and located by a stationary buoy. The **A** area is in the North Eastern part of the lake (Figure 5). It has a 1-mile fetch to the prevailing South Westerly winds. Its bottom is silted, in a slow current part of the lake and the area is secluded from most of the morning sun by trees and hills. The **B** area is more open, has little fetch to the Westerly winds, is inline with the major current flowing into the lake and has more sediment than the A area.

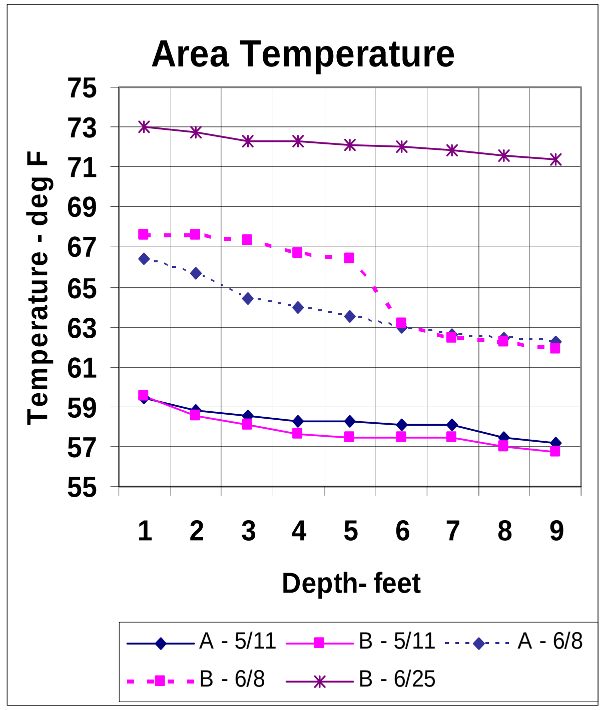


Figure 6: Temperature Profile

Density Stratification:

It was hoped that the lake during treatment would have significant density stratification in order to assist in keeping the herbicide on the lake floor and reduce its ability to mix with the upper water of the lake. This did not happen because of the delay in the treatment date.

The temperature profile (Figure 6) changed significantly from the profile in May to when the treatment was done. In May, the **B** area was 1 degree colder than **A** and both had slight density stratification. On June 8, the density stratification was significant in area **B**, where the temperature changed 4 degrees between the 5 foot and 6 foot level. The **A** area did not have any stratification. By treatment date, the stratification did not exist. A few days prior to treatment, a 20-25 mph wind mixed the lake very well. The temperature was almost uniform from the surface to the 9-foot level, changing by two degrees at a constant slope.

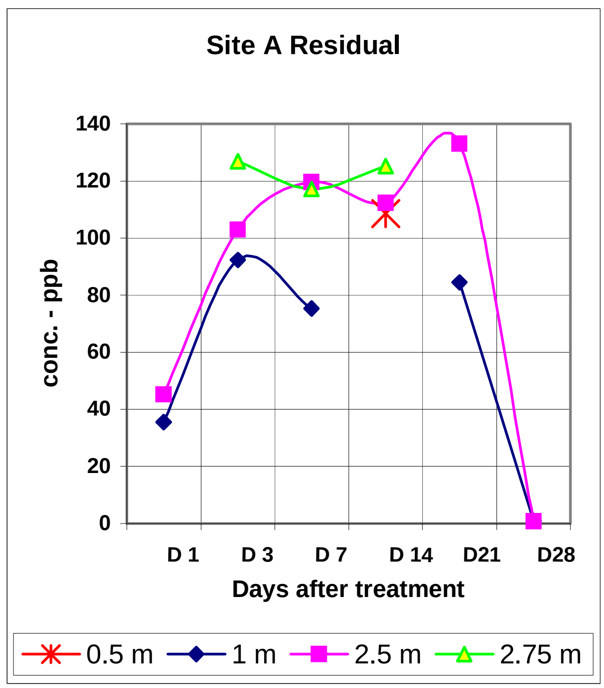


Figure 7: Area A Residual

Herbicide fluctuation in the lake:

The main current into Lower Suncook Lake enters from Narrows Bridge through an inlet channel that is only 2-3 feet deep. This depth may assist in causing the current to split into two parts. The primary current turns Westerly and stays about 100-150 feet off shore through area **B**. It continues around the shore and then turns Southerly through the channel between shore and #1 Island and proceeds to the Lower Suncook river exit to the dam.

The secondary current turns Easterly and follows the North Shore into area **A** where it turns Southerly, continues past all three islands towards the Lower Suncook River exit to the dam.

Lake water samples show the herbicide oscillated throughout the lake from Day 1 through Day 21. By Day 27, the herbicide residual had dropped to about 28 ppb, and was at detection limit on Day 28. The long oscillation period is most likely due to the prevailing weather conditions. From the cloudy overcast day on treatment day, very few cloudless days occurred. The week following Day 21 had most every day with hot and intense sunlight with few clouds. It is this period that the herbicide concentration finally dropped significantly.

On Day 1, lake concentrations were almost uniform at 40 ppb, regardless of depth. On Day 3, herbicide concentration changed with depth. Within 1 foot of the bottom, it was between 110 and 130 ppb. At 2 feet above the bottom, it dropped to between 90 – 105 ppb. Within 1 foot of the surface, it was between 80-90 ppb. The concentrations were higher at site **A**, oscillating about 120 ppb from Day 3 to Day 21 (Figure 7).

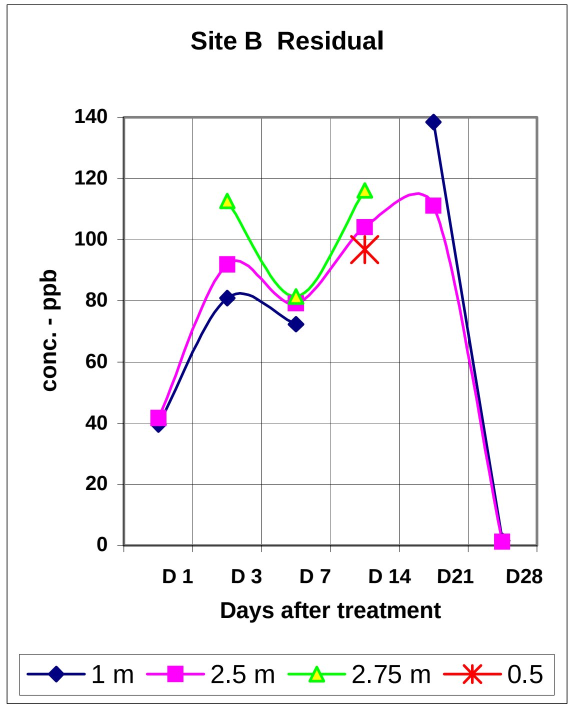


Figure 8: Area B Residual

The concentrations at site **B** (Figure 8) oscillated about 20 ppb less until Day 21 when it spiked to almost 140 ppb close to the surface. This was unusual since most recordings showed higher residual concentrations at the lower levels. This was most likely due to the sweeping of any residual from the inlet channel where two treatment areas were located and a warming of the water as it flowed over the shallow sand bar at the entrance to the lake.

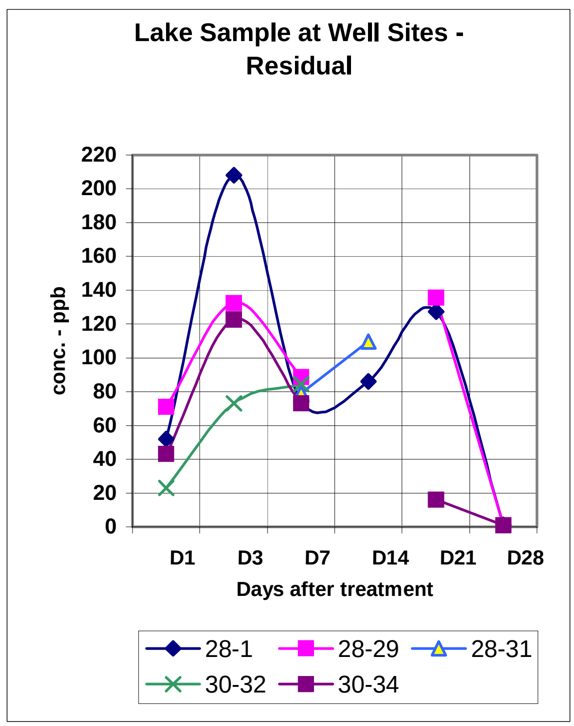


Figure 9: Well Site Locations

Site **A** also spiked on Day 21 to 135 ppb, but this was at the 2.5 meter level. The 1-foot level only recorded an 80 ppb residual. Most likely the current that carried the higher residual had time to cool and fall to the lake bottom by the time it reached site **A**.

The residual concentration near the shore close to the sample wells was also recorded. Well sites 30-32 and 30-34 are in site **A** (Figure 9). Well sites 28-29 and 28-31 are at the Lower Suncook River channel at the exit to the lake. Well site 28-1 is on #1 island, on the side facing the current coming from site **A**.

Site 28-1 reached the highest concentration recorded by any of the samples on Day 3 at just over 200 ppb. This is most likely due to a sweeping of herbicide from the large treatment area of site **A** and the area between this location and the main land. Site 28-1 reached a secondary peak of 120 ppb on Day 21.

The residual near the other well sites peaked on Day 3 at 120 ppb, dropped by 50% on Day 7, and gradually increased to Day 21 except for well site 30-34. On Day 21, its residual was below 20 ppb, indicating that the herbicide was being swept from the area. On Day 21, concentrations down steam were back up to 120 ppb, confirming that the residual was gradually being swept from the lake.

Test Wells:

No herbicide was detected in any of the 5 test wells throughout the study period and up to 60 days post treatment. This adds credibility to the theoretical calculations that predicted no contamination was possible due to the short life of the herbicide and the long time required for any water from the lake to get into a well close to the shore. The test wells were all shallow dug wells and were chosen for their location, use and static level compared to the lake level. All wells were between 5-17 feet from the shore. One was on an island downstream and center to the lake flow. Two had static levels at the lake level. Three had static levels between 4” to 11” above the lake level.

Of the 5 wells, two were used to accelerate the outflow of water and increase the head pressure as a means of testing the model calculations for well contamination. One of the test wells had a static level equal to the lake level and was 17 feet from the shore. The second well had a static level of 1 foot above the lake level and was 15 feet from the shore. Beginning on the day after treatment, water was removed from both wells for next seven days. The volume removed was done in less than 4 minutes so that the head pressure was increased by 5 to 10 times. The volume removed was dependent on the volume of the well and the rate of water inflow. Again, no herbicide was detected.

The Quality Assurance Program Plan is included in the appendix. It discusses the hypothesis for the well tests.

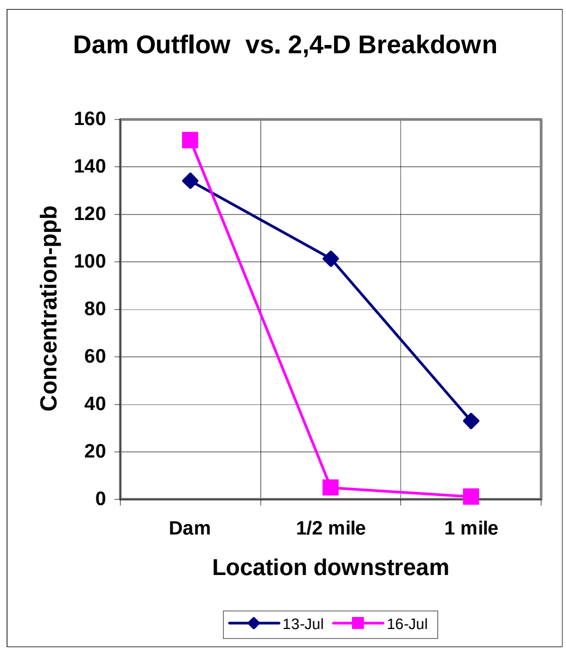


Figure 10: Dam Outflow Residual

Dam Outflow:

Two different conditions of water outflow were sampled for residual concentration. It was found that creating white water with high aeration and agitation significantly reduced the herbicide residual in the outflow water by more than 95%.

Nineteen days after treatment, the herbicide residual was higher than most of the lake surface water, most likely due to the flushing of water through the lake. The dam level was high with the outflow occurring only over the spillway. Little white water was observed at the spillway or in the river leading away from the dam. On July 13, the concentration at the dam was about 135 ppb. Water flow was only over the spillway. There was little white water at the spillway or in the river. Samples at ½ mile and 1 mile downstream recorded concentrations of 100 ppb and about 33 ppb. This was only 24% and 75% reduction respectively (Figure 10). The riverbed was shallow during this period. The reduction of the herbicide concentration is most likely attributed to its contact with organic sediment in the riverbed.

The outflow condition was changed three days later by opening the spillway at the bottom of the dam. The high-pressure discharge created a white stream of water that had a high degree of agitation and aeration. Samples at ½ mile and 1 mile downstream recorded concentrations of 5 ppb and about 1 ppb for a dam sample of 150 ppb. This amounted to 97% and 100% reduction respectively. The reduction of the herbicide concentration is most likely attributed to either aeration or agitation or a combination of both. Most likely, it is due to aeration because long chain organic molecules of similar construction have been found to be easily susceptible to this type of destruction.

3. 2, 4-D Destruction:

A major consideration for the permitting of 2, 4-D for use in treating variable milfoil in NH lakes is the potential for well contamination. The research part of this program designed a treatment experiment to determine if possible techniques could be used to decontaminate well water. The Environmental Research Group of the Civil/Environmental Engineering Department at the University of New Hampshire did the bench scale tests. The outcome produced two approaches with very promising results. One used the UV lamp with a low concentration of peroxide and the other used a standard charcoal water filter. The complete report is included in the Appendix. The report states that the results were performed solely as proof of concept. The next logical step would be to perform a pilot or field test these results on an actually flowing well contaminated with 2, 4-D.

Experimental Design:

Aqua-Kleen Herbicide (27.6 wt.% as 2, 4-D) pellets from Aquatic Control Technology were used to make stock solutions of 10 mg/L of 2, 4-D acid in NH groundwater which had a pH 7.2, total alkalinity of 45 mg/L as $CaCO_3$ and a UV transmittance of 95%. Initial concentrations were chosen at 10 ppm so that slight changes could be observed.

The contaminated groundwater was treated using the following three approaches:

- Direct UV photolysis at 254 nm
- UV photolysis at 254 nm with 50 mg/L of hydrogen peroxide added
- Granular Activated Carbon (GAC) adsorption using Calgon F-300 in isotherm tests

Effectiveness of Processes:

Direct UV photolysis required 900 mj/cm^2 in order to reduce the concentration by 36%. This is significant but may not be cost effective unless well concentrations are just slightly above the MSL of 70 ppb.

UV-peroxide produced very promising results. A 300-mj/cm^2 dose using a 50-ppm concentration of peroxide produced a 40% reduction in the herbicide residual. Increasing the dose to 600-mj/cm^2 and 900 mj/cm^2 produced 89% and 99% reduction respectively. Both results are very promising and should be cost effective for decontaminating any well.

A common GAC used in the home water treatment units was chosen for the test. Freundlich isotherm parameters were estimated to model the data and predict capacity of the GAC for 2, 4-D. The capacity predicted by the model is 2.01 mg of 2, 4-D per gram of GAC. A 5 kg under the kitchen sink filter would protect a family that uses 40 gallons per day for cooking and drinking for 30 days. This filter could be used as a second line of defense for wells that were considered high risk during an herbicide treatment of the lake.

Legislative Action:

The present State statutes, responsibilities, and procedures are not designed to promote the removal of variable milfoil from our lakes and waterways in NH. This can be said after the experience the Suncook Lake Association (SLA) has had in getting a permit to treat the Lower Lake. The procedures and statutes must be changed if variable milfoil is to be stopped from destroying a precious NH asset. Instead of hindering action, it must be changed to promote the assistance of lake associations and volunteers throughout NH. The limited State resources will not be able to effectively control and possibly stop its destruction.

Today, variable milfoil is now recorded to be in 63 lakes and ponds of the 800 that are in New Hampshire. The count has been increasing each year, but the rate of increase has dropped, primarily due to the ‘Lake Host’ volunteer program. Unfortunately, variable milfoil has been recorded to spread from 3 to 10 times the lake area it covers each year. As more plants start from new segments created by natural and boat induced segmentation, more segments are created. A critical density is reached when the density of the milfoil plants reach a point where the recreational value of the lake declines very quickly. Dissolved oxygen in the lake quickly decreases as plant matter increases, significantly reducing the fish population.

In 2001, SLA applied for a permit to treat the Lower Lake. The best herbicide for treatment of variable milfoil is 2, 4-D. The 2001 permit was granted for using Dyquat only, not 2, 4-D. The use of 2, 4-D was not permitted because of the existence of shallow wells near the shoreline. The Dyquat treatment did very little to curtail the growth of milfoil and actually resulted in a waste of the $7,000 treatment cost the Town and State paid.

In 2003, the density of milfoil in Lower Suncook Lake had reached the critical point where if treatment wasn't done in 2004, 1/3 of the lake could not have been used for recreational activities. An appeal was made to State Representatives. It was their effort that opened the door and got the attention of State officials that a critical need for treatment existed. Beginning in October 2003, many volunteers put in hundreds of hours to perform the tasks required to meet the requirements for treatment and comply with the DOA Administrative Laws of Chapter Pes 600 Aquatic Application of Pesticides. A permit to treat using 2, 4-D was granted and received at the last possible moment. SLA had just enough time prior to treatment to perform the necessary tasks and do the treatment so as to minimize the affect on the July 4th weekend for the inhabitants on the lake. The treatment was highly successful and is detailed in this report.

Using this experience, the Suncook Lake Association feels compelled to make recommendations to the State Legislature that will correct the deficiencies in the permitting process. Until milfoil is removed from all the nearby lakes, Suncook Lake will always be susceptible to its re-introduction back into the lake.

RSA 430:41 (IV) states, "It shall be unlawful for any person to handle, transport, store, display, or distribute pesticides in such a manner as to endanger man and his environment or ….". This statute is the basis for 18 pages of administrative laws under Chapter Pes 600. However SLA strongly recommends a separate permitting process has become a necessity due to the destructive nature of milfoil and the low toxicity nature and the high effectiveness at very low concentrations of the 2, 4-D herbicide.

Department of Agriculture, Markets and Food, Division of Pesticide Control is the State organization that issues the special permit for 2, 4-D treatment. The focus of this organization is to oversee the use of pesticides in all aspects of treatments, particularly dealing with food supplies for animals and humans. Paramount to any analysis is their concern first for public health and welfare. Forgotten in this process is that all pesticides (herbicides) are not created equal. Selectivity for use and concentration are critical for proper judgment on its safety.

This concern for public health and welfare has pushed the limits for 2, 4-D herbicide use far beyond the limits that can be supported by scientific analysis. No reports can be found that find herbicide getting into a nearby shallow wells in a lake treatment that does not have a disruptive geology. The theoretical model used by SLA shows that it would take 2 years for herbicide in the lake to reach a well 10 feet from the shore. In this year's treatment, the herbicide concentration in the lake near the surface and near the bottom dropped below detectable limits in 30 days. 5 wells that were between 5-17 feet from shore were tested for herbicide for 60 days after treatment. Two of the five had static water levels at the lake level. Three were between 4" to 11" above lake level. No herbicide was detected in any of these wells. SLA has not found any facts and data that support the denial for use of 2, 4-D when shallow wells are on a lake needing treatment.

The Industry Task Force II on 2, 4-D research data states, "No scientifically documented health risks, either acute or chronic, exist from the approved uses of the phenoxy herbicides. 2, 4-D was the first successful selective herbicide developed in 1946. A selective herbicide is one that controls weeds in a crop without damaging that crop. After 50 years of use, 2, 4-D is still the third most widely used herbicide in the US and Canada, and the most widely used worldwide. Its major uses in agriculture are on wheat and small grains, sorghum, corn, rice, sugar cane, low-till soybeans, rangeland, and pasture." No swimming on Lower Suncook was permitted for the first week of treatment. During the next three weeks, children of all ages were in the lake, even though the herbicide residual was measured at 100 ppb (parts per billion). There were no adverse symptoms reported by anyone.

2, 4-D is very selective and effective in treating variable milfoil. It is delivered in pellet form to the bottom of the lake, and dissolves into the acid from within 24 hours. At that rate, it is absorbed by the milfoil root system during the time when growth is at a maximum. Effective concentrations are only 2 ppm at the root. Measured concentrations near the surface of Lower Suncook Lake averaged at 100 ppb, which is very close to the safe limit for drinking of 70 ppb. Microbe action in the silt found on the bottom of most lakes is responsible for 2, 4-D destruction. The low lake water concentration and susceptibility to microbe destruction make it reaching a nearby well highly unlikely.

Lake area treatment should not be restrictive. Critical to the removal of milfoil in any lake is to remove all of it at the same time. The desire to minimize herbicide treatment can only be effective if lake area is not used to restrict the treatment area. Any restriction of coverage will certainly require the use of herbicide in future years.

Tests on the water outflow also demonstrated how effectively aeration and agitation reduced herbicide concentrations. The use of lake water for industrial processes should not be used to prevent herbicide treatment. The herbicide can be broken down be known methods before it is used for any processes. Effort to do this should be permitted so that treatment could proceed.

The Suncook Lake Association is strongly recommending that the State of NH re-examine the permitting process for 2, 4-D use in treating variable milfoil in NH lakes. Consideration should be given to changing the permitting process by making the permitting agency the Department of Environmental Services. The focus of DES is to balance the protection of public health with the need to protect the waterways of NH. The people in this department understand the critical need for its use, and are not focused on pesticides for pesticide sake.

DOA focus prohibits a balanced approach. An example of this is the Massachusetts DEP position on the use of 2, 4-D. They purport a model that requires a setback distance of 200 feet. Nowhere do they show tests that confirm the model. A theory untested is nothing more than wishful thinking, and can be used to justify their primary concern for public health. In other words, the model and constants were chosen and assumptions made that justify their desired outcome. To our knowledge, NH-DOA has not produced any data that could support the reason for denial of use of 2, 4-D when shallow wells were present around a waterway that needed treatment.

A second reason given by DOA for restricting the use of 2, 4-D was the potential for liability if a well does become contaminated. SLA in partnership with UNH did proactive testing on potential means that could be used to decontaminate a well. The tests concluded that two means were very promising, and could be very cost effective. One is the simple use of a standard charcoal filter. It is SLA's opinion that further research with UNH should be done to develop a method that is available if such an event occurs. With proper consideration, this should eliminate the liability issue for preventing the use of 2, 4-D for milfoil treatment.

New Hampshire can do better. Research funds are now available to permit more use of this herbicide under the watchful guidance of technical personnel. With the advent of the Internet, communication is greatly enhanced reducing the travel needs by these people. The time has come for NH to create a structure that permits the proper resources to be used in the fight to save our waterways.

Critical to the re-examination is the permitting requirements, the conditions of treatment, and the cost of notification. SLA had many meetings, had signatures from everyone on the lake about the treatment date, and was in contact with most by email. Yet, the Administrative Rules required registered mail notification with return receipt. For the size of Lower Suncook Lake, this amounted to about $1000. The same notification conditions had to be repeated when the treatment was delayed by 20 days because of administrative issues and the State's approval process. It cost SLA an additional $1000 to send out the change notice. Signatures from people who attended the meetings should have been used to reduce this cost. If the State needs to count on the help of volunteers, then it needs to re-examine all the tasks and costs associated with doing the treatment.

Finally, a variable milfoil infestation is so destructive that its presence will reduce property values. A DES study suggests that a devaluation of up to 15% has occurred. A critical question can be made to the Legislature about the quality of lakes in New Hampshire all of which are the responsibility of the State. What is the State's responsibility to the owners of property around State owned lakes to protect the lake so that property devaluations do not occur? There is no other condition that occurs with the use of herbicides in the protection of property than with the treatment of exotic aquatic plants such as variable milfoil. This fact should provide the impetus for separate consideration for a new method of permitting for the treatment of lake exotic plant infestations.

Lake Treatment Program:

STOP Milfoil best describes the treatment program used by Suncook Lake Association. The acronym stands for the order of steps in the program; Survey, Treat, Observe, Pull, and Monitor.

SURVEY:

Critical to the program is the ability to know where all domestic water supplies around the lake are in relation to the shore and the area of the lake that needs treatment. Special notification must be made to owners of property that use water directly from the lake through a black pipe or have shallow wells within 75 feet of the treatment area. In order to gather all this information, SLA sent out a fact sheet with a questionnaire, followed up with door to door visit and a second notice for a general informational meeting. At the meeting all questions were answered and the NH Lake Association film “Under Attack” was shown. This film is credited with answering many questions and providing excellent visual information to those unfamiliar with milfoil.

Also critical to the program is the ability to verify the location of **all** milfoil plants in the lake. A Signaling Scuba Tow (SST) was developed that would give a diver under water the ability to notify the people onboard the boat of a milfoil sighting without having to surface. The SST also provided important steerage ability so that the diver could control his depth in order to miss plants or go lower to maintain a visual sighting of the bottom. A safety ball is positioned about 5 feet in front of the diver before the boat starts. This provides a visual location of the diver for the observer onboard the boat who keeps vigil for boat traffic and diver safety.

When the diver pushes a switch, it rings a bell and turns on a light next to the computer operator on the boat. The computer is a laptop placed inside a box to shade the screen. The computer operates on an inverter that converts 12 vdc to 120 vac. Attached to the computer is a USB Earthmate GPS receiver that provides real time location when used with the DeLorme 5.0 TOPO mapping program. When the diver signals, the computer operator positions the cursor on the boat location and clicks the mouse button. This leaves a small buoy on the boat track.

The diver is towed from 1.5 to 2.5 mph. The computer operator provides heading information to the boat captain so that uniform and parallel tracks are made over the water. If the boat captain has a depth sounder or fish finder that shows the bottom, then a determination can be made of the range of depth that milfoil will occupy. This depth will vary from lake to lake because lakes turbidity controls the amount of sunlight reaching the bottom of the lake. At some depth, the amount of light will not support milfoil growth. In Lower Suncook Lake, this was 12 feet.

At 2 mph, a diver can stay underwater for about 1.5 hours with one tank of air. The ideal working depth is about 4-5 feet above the bottom. This provides a good survey of a wide area so that he can see plants off to both sides of the boat track. One diver can cover a width of about 20 feet with a water visibility of 10-15 feet. Two divers pulled from each corner of the boat will cover about 30 – 35 feet.

Before starting the survey, the diver must become neutrally buoyant for the working depth. The SST will control downward about 25% of the rope length at 1.5 mph, and about 33% at 2.5 mph. At 2 mph, the diver will need about 50 feet of rope to be able to reach a depth of 12 feet.

The entire lake must be surveyed in areas that may have milfoil growth. In Lower Suncook Lake, milfoil was found in 95% of areas that would support milfoil. Once all areas are surveyed, then a map is made that lays out the treatment zones as well as those zones that do not need treatment. This map can then be converted into GPS coordinates that the treatment boat will use to guide the spread of the herbicide.

TREAT:

<u>All areas of milfoil must be treated</u>. Any milfoil left in the lake will produce segments that will start new plants within three weeks of the treatment. If all the plants are not treated, then future

treatments will be required. Any property owners that object should be put on notice that they are endangering the property value of their neighbors and potentially subjecting their lake to a loss of recreational areas that will never be recovered without great expense.

The treatment should use 2, 4-D herbicide pellets at an effective dose of 100 pounds per acre. This will produce a 2-ppm concentration at the roots of the milfoil plants. This coverage rate can change because of pH or hardness. The applicator should be asked to determine the best coverage. Too low a coverage rate will cause a poor or incomplete root kill. Too high a coverage in the 150 – 200 pounds per acre range is reported to cause an excessively quick kill of the plants leaf system so that insufficient uptake of the herbicide by the root system occurs. In both cases, an ineffective treatment occurs.

The treatment must require the guidance of a GPS controlled applicator boat. The use of GPS guidance is the only method that can guarantee that all milfoil plants will receive a treatment. The applicator should then supply a copy of the actual treatment area and the amount of herbicide used to confirm the rate of treatment and the area of coverage agrees with the diver-generated survey.

OBSERVE:

It is important to verify that the treatment was effective and locate any surviving plants so they can be removed as soon after treatment as possible. Several weeks after treatment, divers can begin surveying the lake for results. The first areas that should be surveyed are areas that were not treated and are on the shallow limits of milfoil growth. Some shallow areas may have pockets of silt that support milfoil where most shallow areas have sand beds that are devoid of most plant life.

The next areas that should be surveyed are those that could be suspect areas. These are areas that may be upstream of a treatment zone and were not surveyed because of difficult diver access, or in our case, a lack of time prior to treatment. Finally by the fourth week, various points in the treatment zones must be checked. Dying milfoil will have a brownish green or yellow appearance, show defoliation of the stalks, and a falling back of the stalks toward the bottom. Critical to this survey, any plants that do not show symptoms of treatment must be located and planned for diver removal the following week.

PULL:

A grid mapping system for a lake is described in the QAPP found in the appendix. All plants that have survived treatment must be located on this grid system. A program for removal is established starting with those plants furthest up current. The date of first removal of plants in each grid is recorded. Three mop-up visits are required before any certainty can be made that all roots have been removed. Each visit must wait two weeks so that any surviving roots can generate new shoots that provide a visual clue of the surviving roots.

This program will then require a multiplexing of plant removal in grids around the lake as well as mop-up dives for previously removed plants. The amount of diver activity required for this phase of the program is directly related to the completeness of the survey and accurate location of all plants prior to treatment, and the effectiveness of the application on treatment day. Extra effort in these areas will greatly reduce the amount of diver time post treatment.

MONITOR:

Prior to treatment, the Lake Association should start or reinforce the ‘Lake Host’ program as developed by the NH Lakes Association. With the lake treatment, emphasis shifts to prevention – preventing any boats entering the lake from bringing in new milfoil segments. Critical to this process is the visual inspection of boats and trailers prior to entering the water. Critical to the success is the requirement that all boats be inspected.

Most important is having a person available at the ramp(s) when boats are being removed for the winter by the different marinas. Most of this activity is removing boats from the treated lake, putting them into slips (prime areas for milfoil growth) at an untreated lake for temporary storage, and then going back to the treated/clean lake to pick up another boat. Of course, this is repeated the next spring. The inspection of this type of activity is critical to the future success of the treatment program. Notice should be made to the marinas that serve the lake that their activity must be monitored and request that they have their people examine the boat/trailer each and every time before entering and exiting the treated lake. Lake Host or equivalent monitoring of marina activities and performance is strongly recommended.

Also critical to the success is to have divers re-survey the lake twice each year following treatment. Any plants found must be recorded on a grid system and scheduled for removal as described in the previous section. The Lake Association should start an annual fund to support this activity and pay the people that participate. It is extremely important to maintain this activity for the foreseeable future.

The Lake Association should ask anyone on the lake in kayaks or canoes to keep looking for new plants. This effort should not be overlooked, since it can provide may hours of effective observation and did result in a major ‘save’ in the Lower Suncook Lake treatment.

Appendix A – Report Pictures:

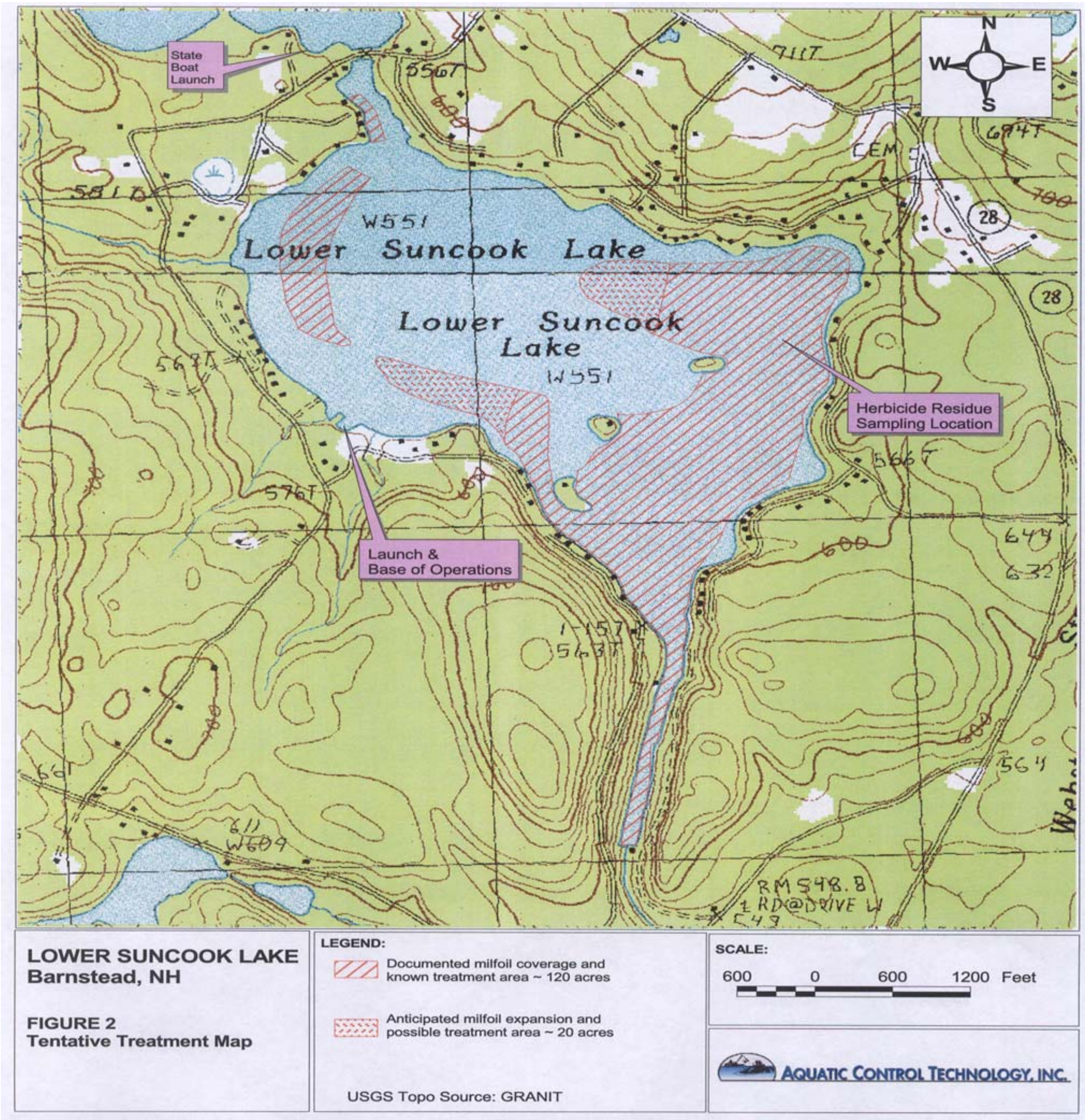


Figure 1: 2003 Survey

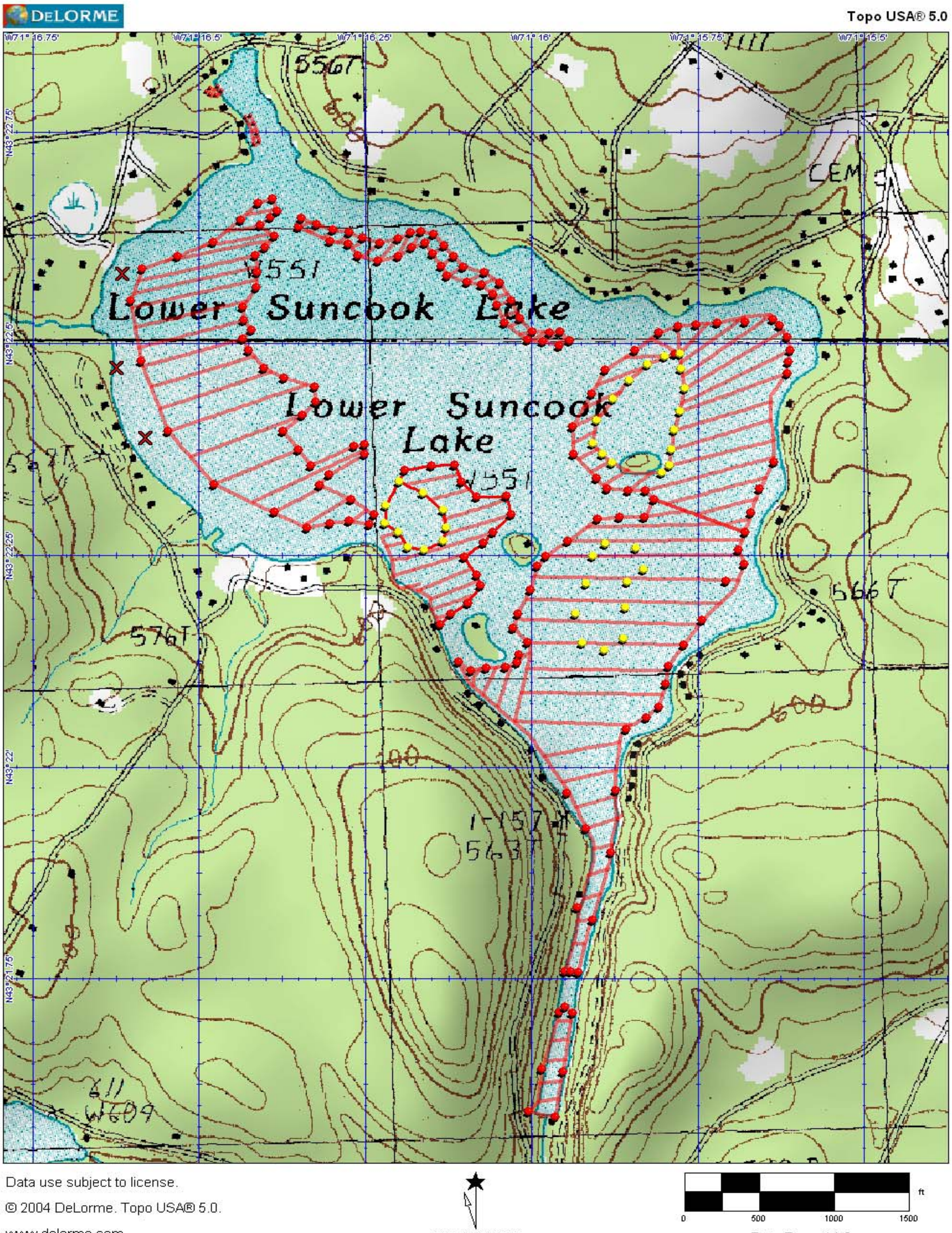


Figure 2: 2004 Survey

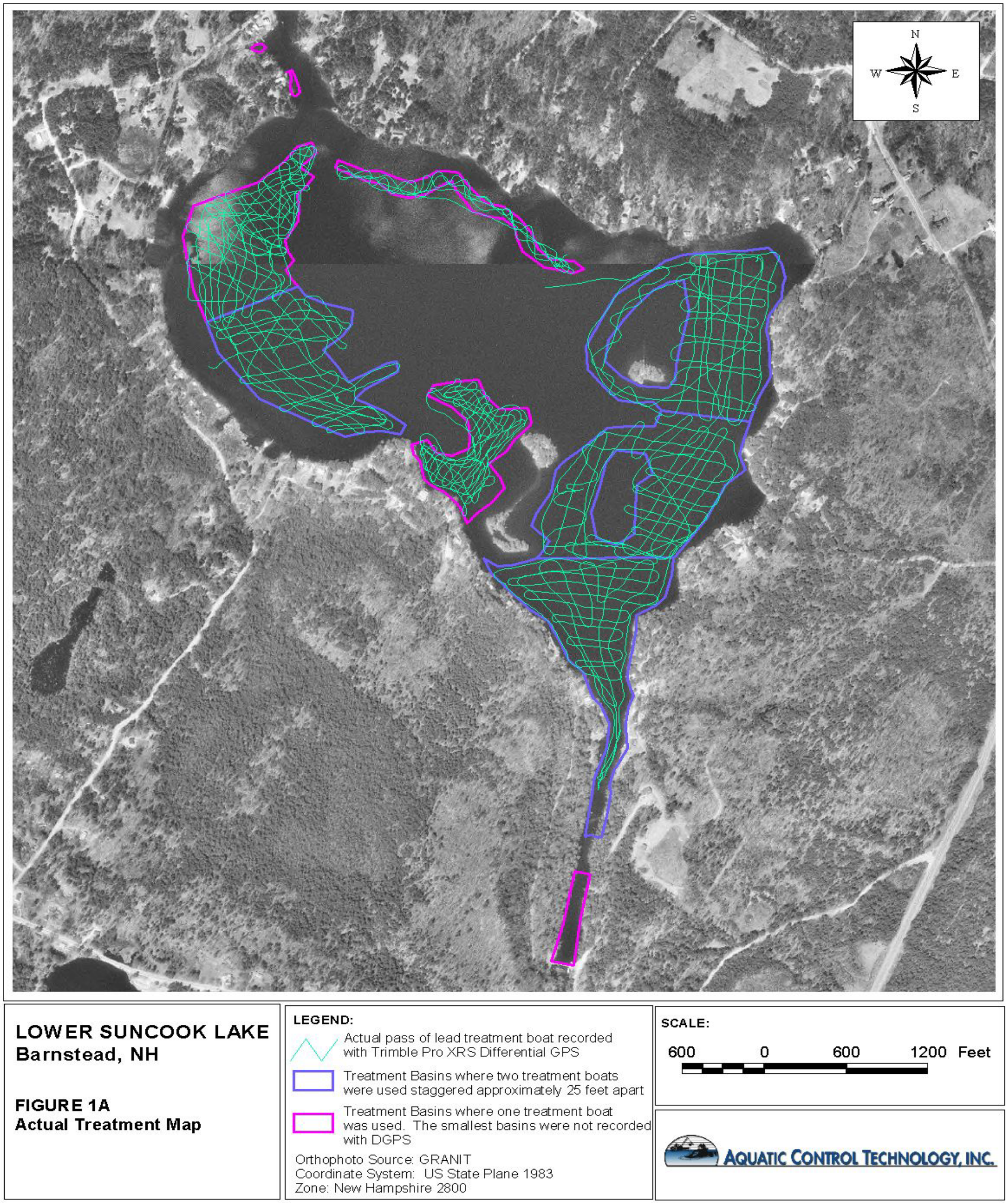


Figure 3: Aquatic Control Treatment

Figure 4: Pre & 6 day Post Treatment

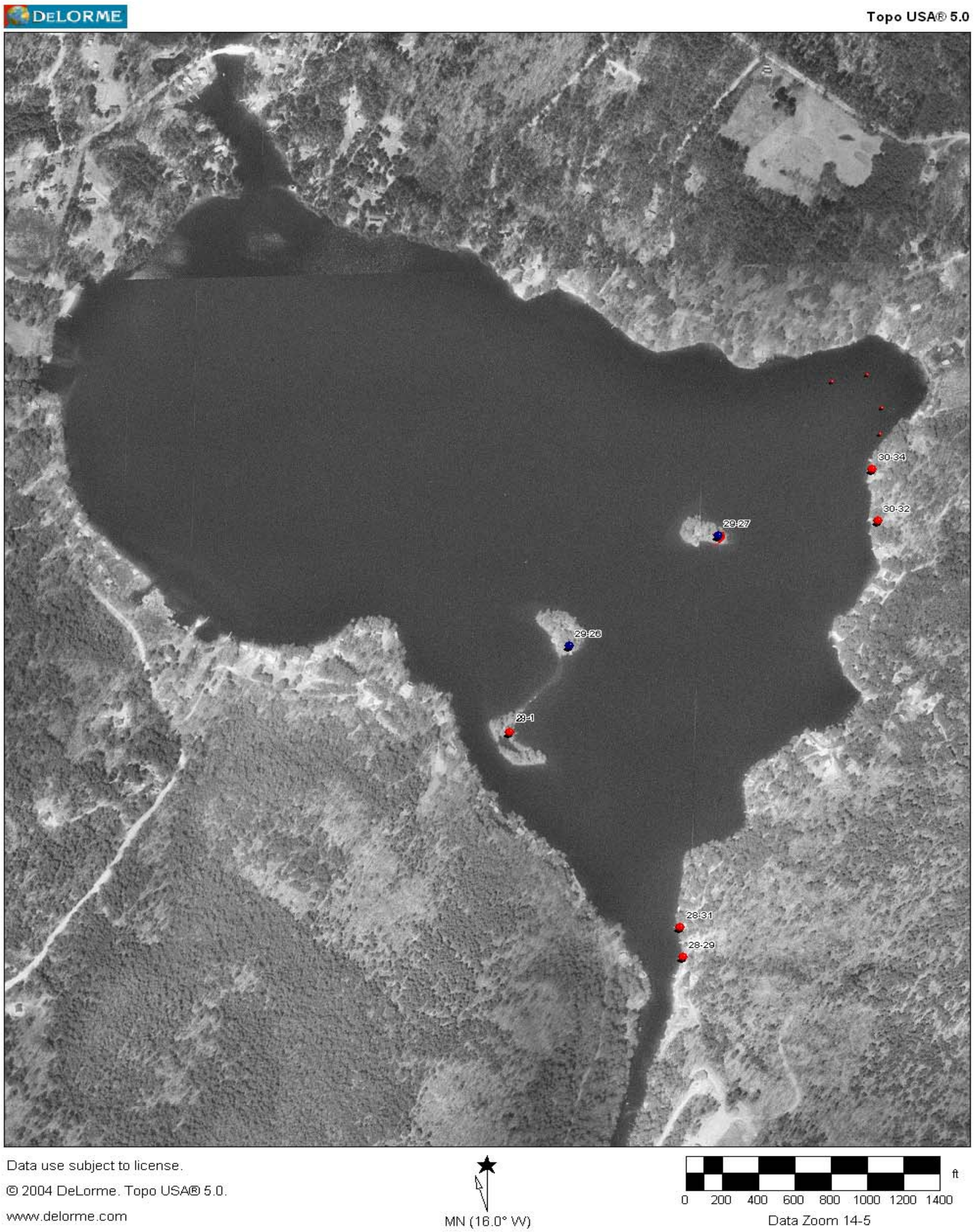


Figure 5: Lower Suncook Lake (test well sites)

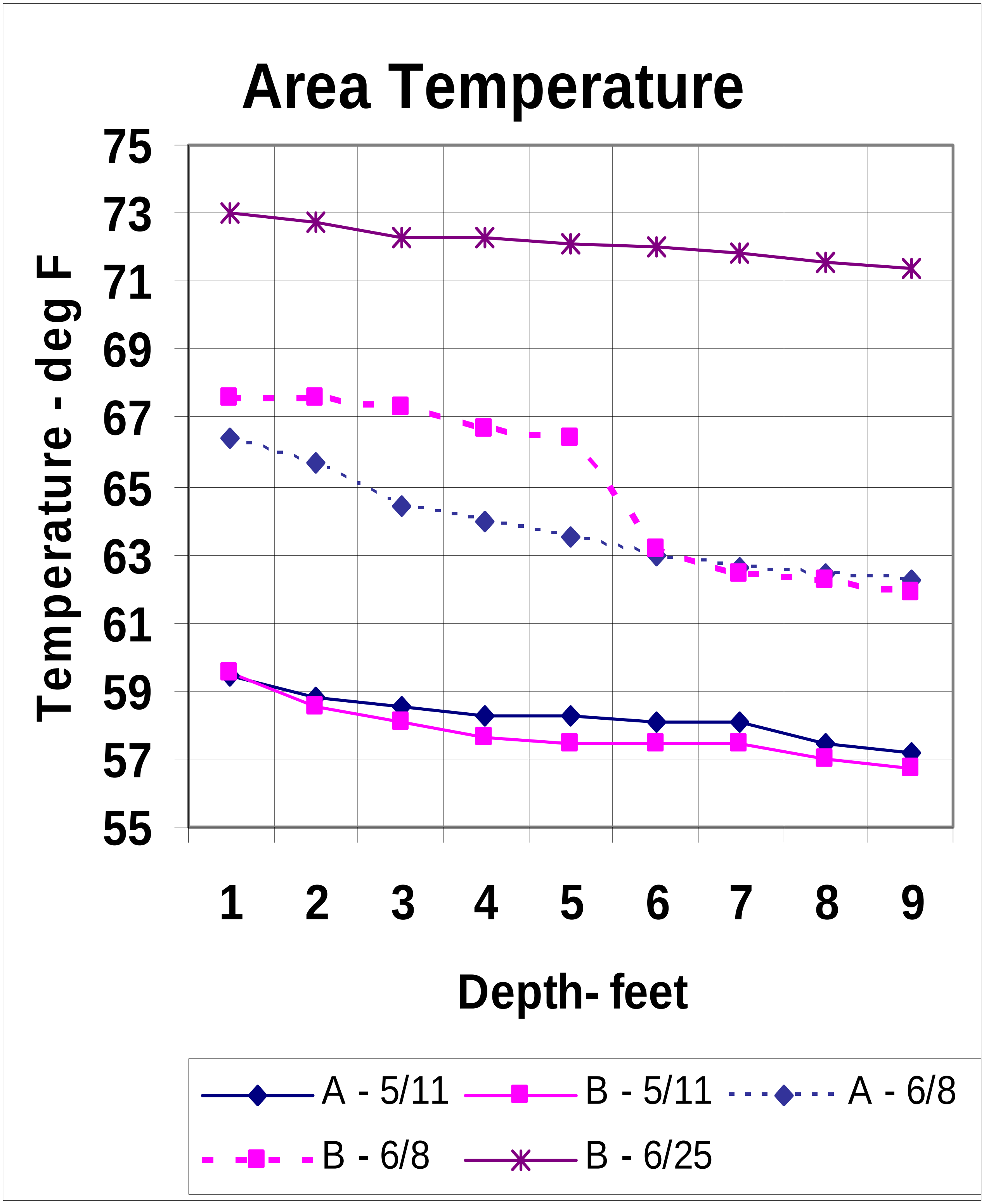


Figure 6: Temperature Profile

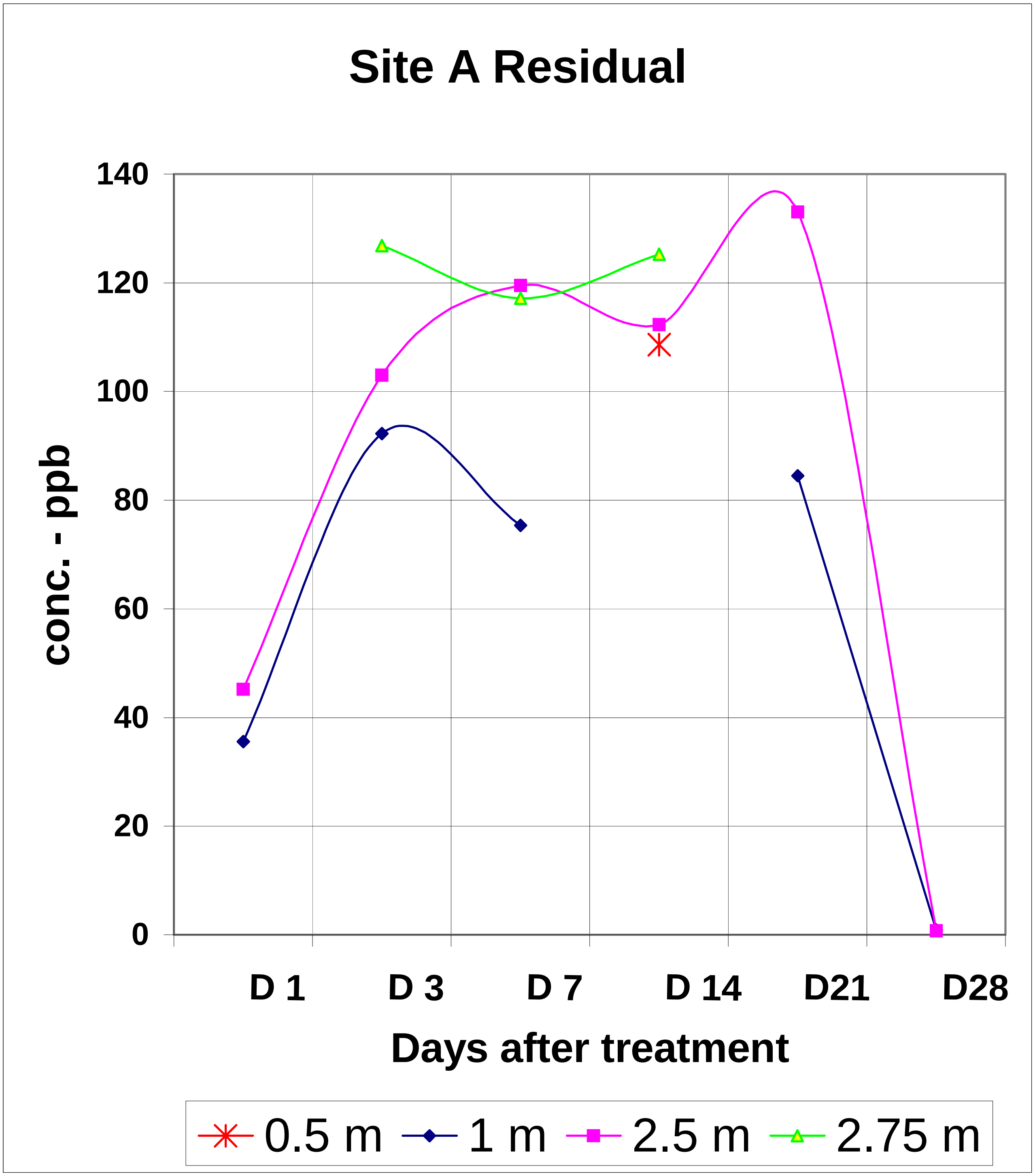


Figure 7: Area A Residual

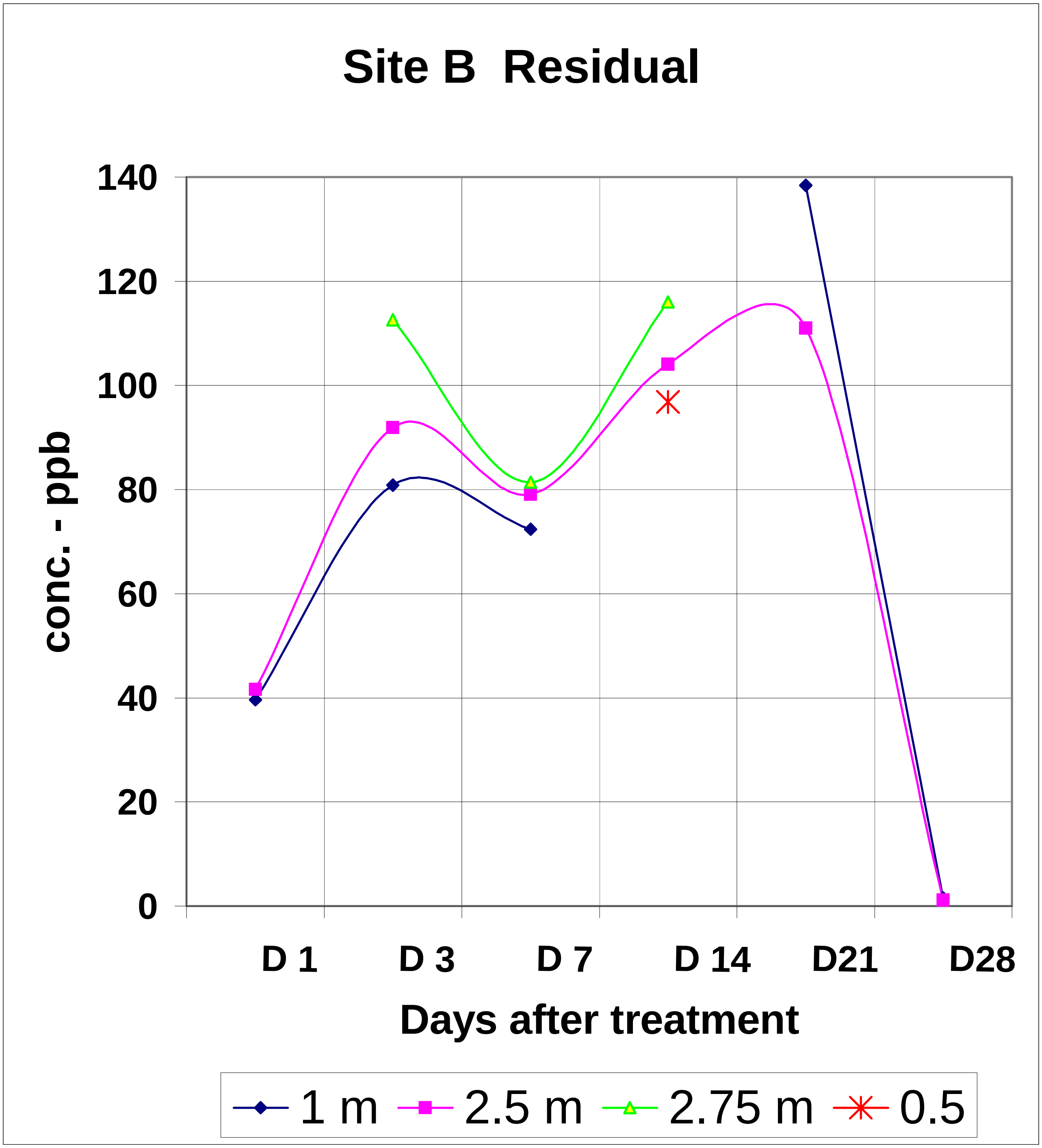


Figure 8: Area B Residual

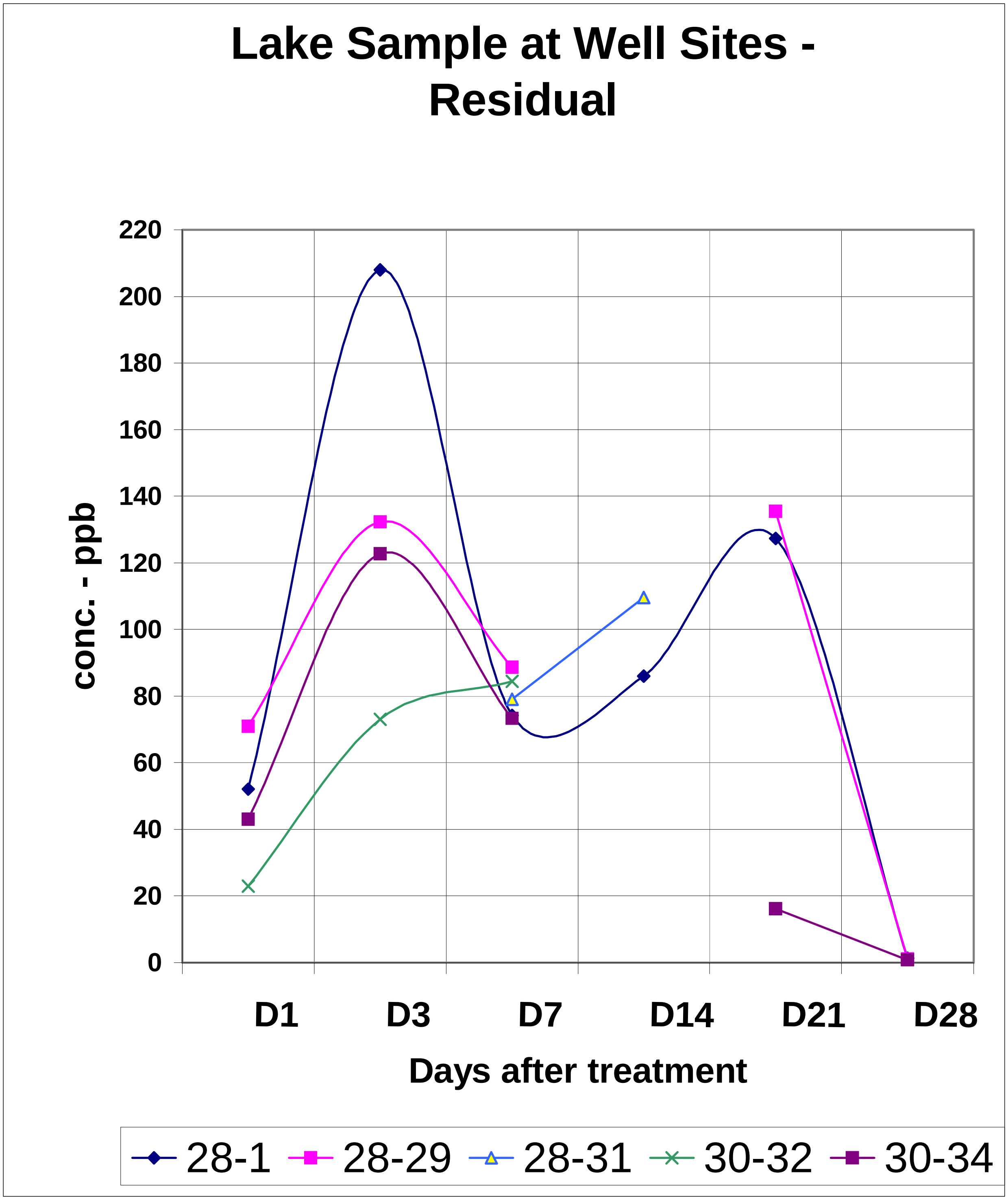


Figure 9: Well Site Locations

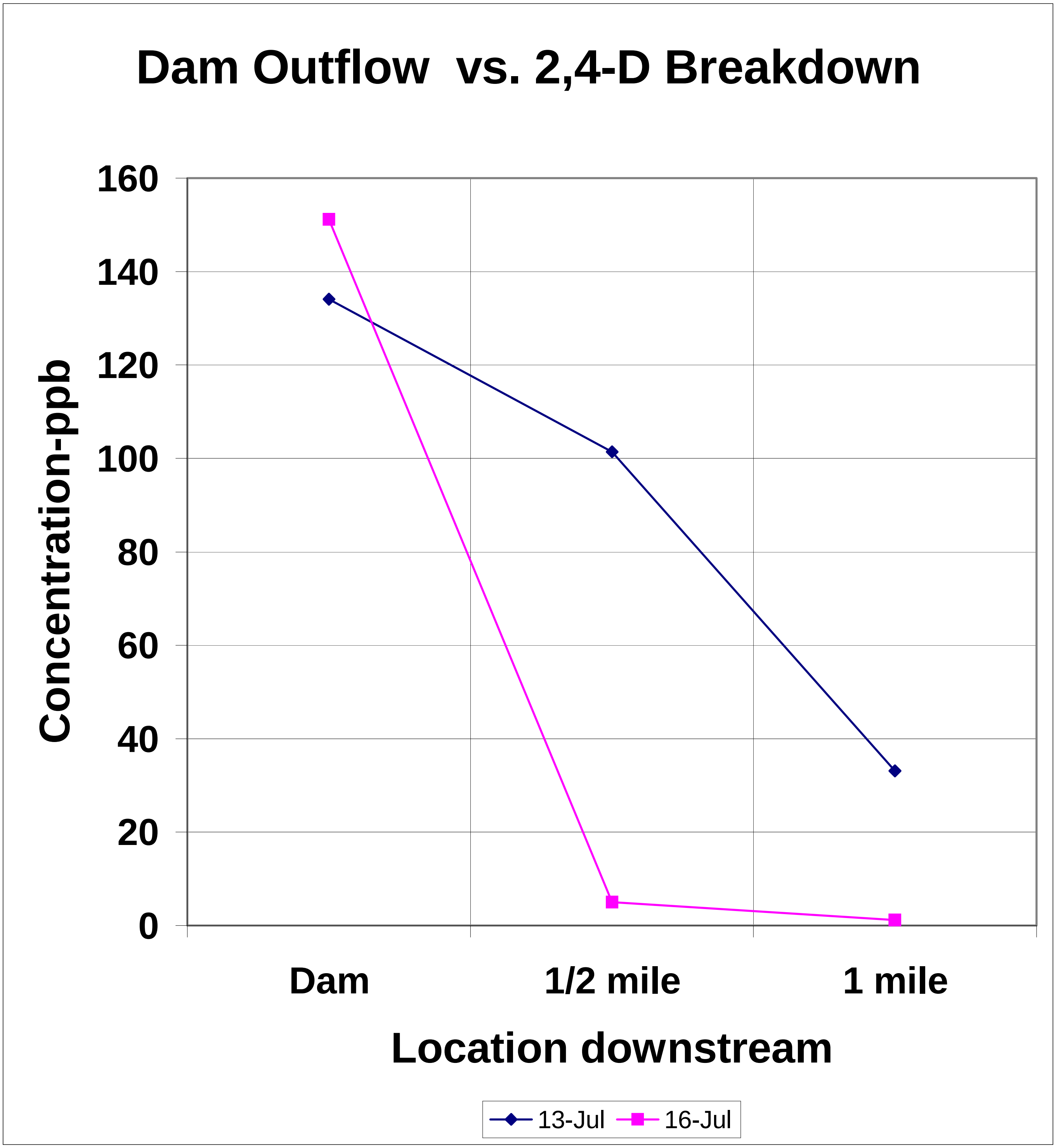


Figure 10: Dam Outflow Residual

Appendix B – Water Sample Data:

data sheet

Date	Site	location	depth	conc.
			feet	
24-Jun	28-1	well		0
24-Jun	28-31	well		0
24-Jun	30-32	well		0
24-Jun	30-34	well		0
24-Jun	A - 122	lake		0
24-Jun	B-123	lake		0
26-Jun	28-1	lake	0.5	52
26-Jun	28-29	lake	0.5	70.9
26-Jun	30-32	well		0
26-Jun	30-32	lake	0.5	23
26-Jun	30-34	well		0
26-Jun	30-34	lake	0.5	43.06
26-Jun	A	lake	3	35.6
26-Jun	A	lake	7.5	45.2
26-Jun	B-123	lake	3	39.6
26-Jun	B-123	lake	7.5	41.6
28-Jun	28-1	lake	0.5	208
28-Jun	28-1	lake	0.5	35.6
28-Jun	28-1	well	0.5	0
28-Jun	28-1	well	0.5	0
28-Jun	28-29	well	0.5	0
28-Jun	28-29	lake	0.5	132.3
28-Jun	30-32	well	0.5	0
28-Jun	30-32	lake	0.5	103.6
28-Jun	30-34	well	0.5	0
28-Jun	30-34	lake	0.5	122.7
28-Jun	A	lake	3	92.3
28-Jun	A	lake	7.5	103
28-Jun	A	lake	8.25	127
28-Jun	B	lake	3	80.89
28-Jun	B	lake	7.5	91.9
28-Jun	B	lake	7.5	99.1
28-Jun	B	lake	8.25	112.6
2-Jul-04	28-1	well		0.5
2-Jul-04	28-29	well		0.34
2-Jul-04	28-31	well		0.49
2-Jul-04	30-32	well		0.33
2-Jul-04	30-34	well		0.45
2-Jul-04	28-1	lake		74.2
2-Jul-04	28-29	lake		88.61
2-Jul-04	28-31	lake		79.12
2-Jul-04	30-32	lake		84.41
2-Jul-04	30-34	lake	0.5	73.27
2-Jul-04	30-34	lake	Field Rep	72.68
2-Jul-04	A	lake	I m	75.37
2-Jul-04	A	lake	2.5m	119.54
2-Jul-04	A	lake	2.75m	117.14
2-Jul-04	B	lake	1m	72.39
2-Jul-04	B	lake	2.5m	79.12
2-Jul-04	B	lake	2.75m	81.40

Date	Site	location	depth	conc.
			meter	
26-Jun	28-1	lake	0.2	52
28-Jun	28-1	lake	0.2	208
2-Jul	28-1	lake	0.2	74.2
9-Jul	28-1	lake	0.2	86.0
16-Jul	28-1	lake	0.2	127.3
23-Jul	28-1	lake	0.2	1.3
26-Jun	28-29	lake	0.2	70.9
28-Jun	28-29	lake	0.2	132.3
2-Jul	28-29	lake	0.2	88.61
16-Jul	28-29	lake	0.2	135.4
23-Jul	28-29	lake	0.2	1.0
2-Jul	28-31	lake	0.2	79.12
9-Jul	28-31	lake	0.2	109.6
26-Jun	30-32	lake	0.2	23
28-Jun	30-32	lake	0.2	73
2-Jul	30-32	lake	0.2	84.41
26-Jun	30-34	lake	0.2	43.06
28-Jun	30-34	lake	0.2	122.7
2-Jul	30-34	lake	0.2	73.27
16-Jul	30-34	lake		16.17
23-Jul	30-34	lake	0.2	0.8
26-Jun	A	lake	1	35.6
28-Jun	A	lake	1	92.3
2-Jul	A	lake	1	75.37
9-Jul	A	lake	**0.5**	108.6
16-Jul	A	lake	1	84.5
23-Jul	A	lake	1	0.9
26-Jun	A	lake	2.5	45.2
28-Jun	A	lake	2.5	103
2-Jul	A	lake	2.5	119.54
9-Jul	A	lake	2.5	112.3
16-Jul	A	lake	2.5	133.0
23-Jul	A	lake	2.5	0.7
28-Jun	A	lake	2.75	126.9
2-Jul	A	lake	2.75	117.14
9-Jul	A	lake	2.75	125.3
26-Jun	B	lake	1	39.6
28-Jun	B	lake	1	80.89
2-Jul	B	lake	1	72.39
9-Jul	B	lake	**0.5**	96.8
16-Jul	B	lake	1	138.4
23-Jul	B	lake	1	1.6

data sheet

Date	Site	location	depth	conc.
			feet	
9-Jul-04	28-1	well		0.1
9-Jul-04	30-34	well		0.1
9-Jul-04	30-32	well		0.3
9-Jul-04	28-31	well		0.1
9-Jul-04	28-31	well	Lab Split	0.2
9-Jul-04	28-1	lake		86.0
9-Jul-04	28-31	lake		109.6
9-Jul-04	Channel			82.3
9-Jul-04	Channel		Lab Split	76.3
9-Jul-04	B	lake	.5M	96.8
9-Jul-04	B	lake	2.5m	104.0
9-Jul-04	B	lake	2.75m	116.1
9-Jul-04	A	lake	.5m	108.6
9-Jul-04	A	lake	2.5m	112.3
9-Jul-04	A	lake	2.75m	125.3
9-Jul-04	B1	lake	0.5ft	108.6
9-Jul-04	B1 Rep 1	lake	0.5ft	106.0
9-Jul-04	B1 Rep 2	lake	0.5ft	104.5
9-Jul-04	B2	lake	0.5ft	115.0
16-Jul	28-1 Well	well		0.47
	28-1 Well (lab replicate)	well		0.36
16-Jul	28-29 Well	well		0.42
16-Jul	28-31 Well	well		0.51
16-Jul	30-32 Well	well		0.95
16-Jul	30-34 Well	well		0.47
16-Jul	28-1 Lake	lake		127.28
	28-1 Lake (lab replicate)	lake		120.19
16-Jul	28-29 Lake	lake		135.38
16-Jul	30-34 Lake	lake		16.17
19-Jul	Zero standard			0.77
16-Jul	A-1m		1 m	84.47
16-Jul	A-2.5m		2.5 m	133.02
16-Jul	B-1m		1 m	138.40
16-Jul	B-2.5m		2.5 m	111.02
16-Jul	Rt 28 Bridge			5.05
16-Jul	144 Camp			1.17
16-Jul	Dam			151.15

Date	Site	location	depth	conc.
			meter	
26-Jun	B	lake	2.5	41.6
28-Jun	B	lake	2.5	91.9
28-Jun	B	lake	2.5	99.1
2-Jul	B	lake	2.5	79.12
9-Jul	B	lake	2.5	104.0
16-Jul	B	lake	2.5	111.0
23-Jul	B	lake	2.5	1.2
28-Jun	B	lake	2.75	112.6
2-Jul	B	lake	2.75	81.40
9-Jul	B	lake	2.75	116.1
23-Jul	28-1	well		0.4
23-Jul	28-29	well		0.6
23-Jul	28-31	well		0.5
23-Jul	30-32	well		0.6
23-Jul	30-34	well		0.4
23-Jul	30-34	well		0.6
23-Jul	Bow Lake	lake		0.6
23-Jul	28-1 Lake	lake		1.3
23-Jul	28-29 Lake	lake		1.0
23-Jul	30-34 Lake	lake		0.8
23-Jul	Dam	0.9		0.9
23-Jul	Rt 28	River		1.0
23-Jul	Camp	River		1.0
23-Jul	A	lake	1 m	0.9
23-Jul	A	lake	2.5 m	0.7
23-Jul	B	lake	1 m	1.6
23-Jul	B	lake	2.5 m	1.2
23-Jul	A Gerry Lane	lake		1.0
23-Jul	B2 Morrin	lake		1.3
23-Jul	B Sunset	lake		0.9
23-Jul	B Sunset	lake		1.2
23-Jul	Control			34.5

Site A		
Date	**depth**	**conc.**
	meter	
26-Jun	1	35.6
26-Jun	2.5	45.2
28-Jun	1	92.3
28-Jun	2.5	103
28-Jun	2.75	126.9
2-Jul	1	75.37
2-Jul	2.5	119.54
2-Jul	2.75	117.14
9-Jul	**0.5**	108.6
9-Jul	2.5	112.3
9-Jul	2.75	125.3

Site B		
Date	**depth**	**conc.**
26-Jun	1	39.6
26-Jun	2.5	41.6
28-Jun	1	80.89
28-Jun	2.5	91.9
28-Jun	2.75	112.6
2-Jul	1	72.39
2-Jul	2.5	79.12
2-Jul	2.75	81.40
9-Jul	**0.5**	96.8
9-Jul	2.5	104.0
9-Jul	2.75	116.1

Dam Outflow

Date	**Location**	**Conc.**
13-Jul	Spillway	135.15
13-Jul	Spillway	133.05
13-Jul	1/2 mile	103.5
13-Jul	1/2 mile	99.26
13-Jul	1 mile	32.74
13-Jul	1 mile	33.43

depth-m	**day after**	**A**
0.5	1	
0.5	3	
0.5	7	
0.5	14	108.6
1	D 1	35.6
1	D 3	92.3
1	D 7	75.37
1	D 14	
1	D21	84.5
1	D28	0.9
2.5	1	45.2
2.5	3	103
2.5	7	119.54
2.5	14	112.3
2.5	21	133.0
2.5	28	0.7
2.75	1	
2.75	3	126.9
2.75	7	117.14
2.75	14	125.3

depth-m	day after	**B**
0.5	1	
0.5	3	
0.5	7	
0.5	14	96.8
1	D 1	39.6
1	D 3	80.89
1	D 7	72.39
1	D 14	
1	D21	138.4
1	D28	1.6
2.5	1	41.6
2.5	3	91.9
2.5	7	79.12
2.5	14	104.0
2.5	21	111.0
2.5	28	1.2
2.75	1	
2.75	3	112.6
2.75	7	81.40
2.75	14	116.1

Outflow	Location	Conc.	% Redctn
spillway	Dam	134.1	
13-Jul	1/2 mile	101.4	24.4%
	1 mile	33.1	67.4%
sluice/splwy	Dam	151.2	
16-Jul	1/2 mile	5.1	96.7%
	1 mile	1.2	76.9%

23-Jul	Dam	0.9
23-Jul	Rt 28	1.0
23-Jul	Camp River	1.0

	13-Jul	16-Jul
Dam	134.1	151.2
1/2 mile	101.4	5.1
1 mile	33.1	1.2

	Site	**28-1**
D1	26-Jun	52.0
D3	28-Jun	208.0
D7	2-Jul	74.2
D14	9-Jul	86.0
D21	16-Jul	127.3
D28	23-Jul	1.3

Site	**28-29**
26-Jun	70.9
28-Jun	132.3
2-Jul	88.6
9-Jul	
16-Jul	135.4
23-Jul	1.0

Site	**28-31**
26-Jun	
28-Jun	
2-Jul	79.1
9-Jul	109.6
16-Jul	
23-Jul	

Site	**30-32**
26-Jun	23.0
28-Jun	73.0
2-Jul	84.4
9-Jul	
16-Jul	
23-Jul	

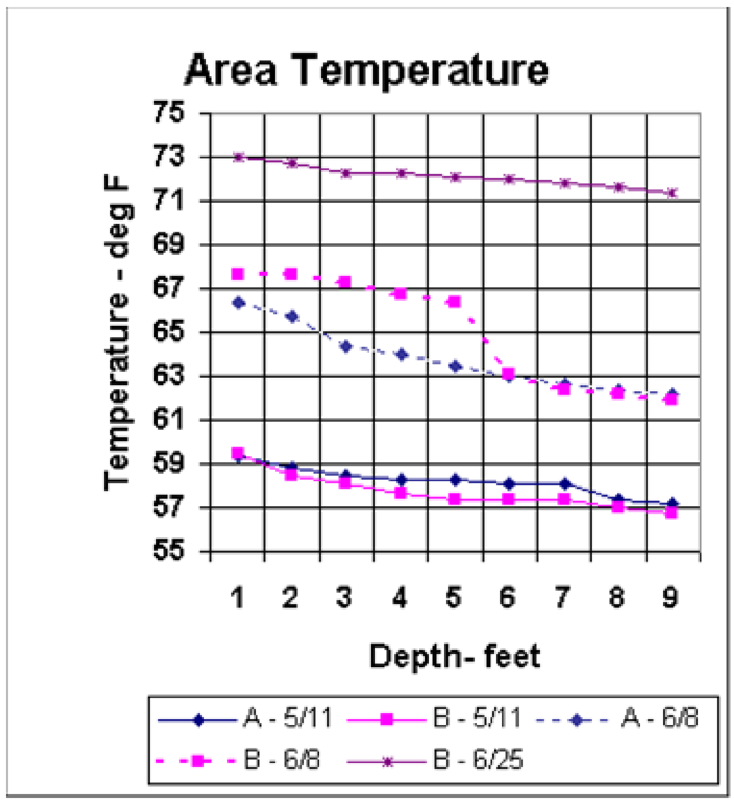
Site	**30-34**
26-Jun	43.1
28-Jun	122.7
2-Jul	73.3
9-Jul	
16-Jul	16.17
23-Jul	0.8

10:30am - May 11, 2004; 3 knt westerly wind

depth	A - 5/11	B - 5/11	drifting	B var	Drift var.
1	59.4	59.5	59.0	59.8	
2	58.8	58.5	58.8	59.0	59.0
3	58.5	58.1	58.6		
4	58.3	57.6	58.3		
5	58.3	57.4	57.9		
6	58.1	57.4	57.7		
7	58.1	57.4	57.6		
8	57.4	57.0	57.2		
9	57.2	56.7	57.0		
bottom	11	9	variable		
boat	steady	swinging	driftin		

	9:56 AM	10:32 AM
6/8/04	A - 6/8	B - 6/8
1	66.4	67.6
2	65.7	67.6
3	64.4	67.3
4	64	66.7
5	63.5	66.4
6	63	63.1
7	62.6	62.4
8	62.4	62.2
9	62.2	61.9
	no wind	4 knts south 74.5f air temp.

B area	6/24/04	B - 6/25
1	73.8	73
2	73.8	72.7
3	73.8	72.3
4	73.6	72.3
5	73.6	72.1
6	73.6	72
7	73.6	71.8
8	73.6	71.6
9	73.4	71.4
	2:54 PM	11:55 AM
	windy	calm



Name	Well dia.	static level	lake level	well above	distance to	gal/foot	cu ft
		typical-in		lake level	shoreline		
28-1	8.0	26.5	27.0	0.5	12 ft	2.6	0.3
28-29	24.3	34.3	45.8	11.5	7 ft	24.1	3.2
28-31	32.3	72.0	75.6	3.6	18 ft	42.5	5.7
30-32	30.3	73.4	85.4	12.0	20 ft	37.4	5.0
30-34	32.0	99.9	101.5	1.6	22 ft	41.9	5.6

Well	30-32	**gallons**		30-34	**gallons**
static level	70		static level	98	
2min pump	89	59.3	150 sec. pump	104.25	21.8
complete pump	4 min.	118.5			
static level	72.25		static level	91.25	
4 min pump	98	80.3	1 min.	106	
recovery			2 min	111	68.9
plus 1 min	96				
plus 2 min	95		**recovery start**	108.75	
plus 4 min	91		plus 2 min	106.75	1
			plus 6 min	105	0.44

Well Static Level

	30-32
26-Jun	70
27-Jun	
28-Jun	72.25
29-Jun	72.5
30-Jun	
1-Jul	71.25
2-Jul	73.375
3-Jul	
4-Jul	
5-Jul	

static level	72.5		static level	91.25	
pump submerged	71.875		pump submerged	90.75	
ve closed, pump on	71.875		valve closed, pump on	90.75	
7:44	71.875		7:11	90.75	
7:45	81.75		7:12	101.25	
7:46	89.25		7:13	109.5	65.4
7:48	99.5		7:13:15	off/out	
7:49	102.5	95.5	7:15	109.75	
pump out			7:16	108.5	1.25
7:50	100		7:18	107	0.75
7:51	98.5	1.5	7:20	105.75	0.625
7:52	97	1.5	7:26	103.5	0.375
7:54	94.5	1.25			

1-Jul

static level	71.25		static level	90.75	
pump submerged	71.5		pump submerged	90.5	
valve closed, pump on	71.375		valve closed, pump on	90.5	
10:33	71.375		10:59	90.5	
10:37	99.5	87.7	11:01	109	64.6
			11:02	off; all out	
			11:03	115	
static level	73.75		11:04	113.75	1.25
pump submerged	73				
valve closed, pump on	73				
4:16	73		static level	97.5	
4:17	83		pump submerged	97.25	
4:18	89.5		valve closed, pump on	97.25	
4:19	95.5		3:58	97.25	
4:20	100	84.2	4:00:20	118	72.4
off/in/valve open			pump in/on/valve closed		
4:20:30	99.75		4:01	117.75	
4:21:00	97.75				
pump out					
4:22	96.5				
4:23	95	1.5			
4:26	91	1.3			

2-Jul

static level	73.375		Static level	99.5	
pump submerged	73		pump in	99.75	
valve closed, pump on	73		7:18	99.75	
6:47	73		7:19	110	35.8
6:48	82.25		out/off		
6:49	89.5				
6:50	95.25				
6:51	99.25	81.9			
6:51:30	out				
6:52:30	98				
6:53:30	97	1			
	total gallons pumped	548.2			329.0

Appendix C – ERG Report:

Batch, Bench-Scale Treatment of 2,4-D Contaminated Well Water

James P. Malley, Jr., Ph.D.
Professor of Civil/Environmental Engineering
University of New Hampshire (UNH)
Environmental Research Group (ERG)
ETB Room 344, 35 Colovos Road
Durham, NH 03824-3591 USA
Voice: (603) 862-1449 E-mail: jim.malley@unh.edu

October 20, 2004
UNH, Durham, NH 03824

Research Approach

- **Aqua-Kleen Herbicide (27.6 wt.% as 2,4-D) from Aquatic Control Technology, Inc. used**
- **Stock Solutions of 10 mg/L as 2,4-D were prepared in a New Hampshire Groundwater**
- **Groundwater Quality: pH 7.2; Total Alkalinity 45 mg/L as $CaCO_3$; UV Transmittance 95%**
- **2,4-D Contaminated Groundwater Samples were Treated Using Three Approaches:**
    - **Direct UV Photolysis at 254nm**
    - **UV Photolysis at 254nm with 50 mg/L of hydrogen peroxide added**
    - **Granular Activated Carbon (GAC) Adsorption using Calgon F-300 in Isotherm Tests**

Research Results For UV Alone

Treatment	Percent* Removal 2,4-D	Notes
UV Alone Dose 300 mJ/cm2	**6.6%**	**Not Significant****
UV Alone Dose 600 mJ/cm2	**16.9%**	**Significant - Not Cost Effective**
UV Alone Dose 900 mJ/cm2	**36.3%**	**Significant - Not Cost Effective**

* Initial Concentration of 2,4-D = 10.08 +/- 0.03 mg/L
**Not Statistically Significant at the 95% Confidence Interval – Student-t Test

Research Results For UV-Peroxide

Treatment	Percent** Removal 2,4-D	Notes
UV Dose* 300 mJ/cm2	**41.6%**	**Significant - Not Cost Effective**
UV Dose* 600 mJ/cm2	**88.8% (1.13 mg/L)*****	**Very Promising Results**
UV Dose* 900 mJ/cm2	**99.1% (0.09 mg/L)*****	**Very Promising Results**

* 50 mg/L hydrogen peroxide added to the sample prior to UV Dose
** Initial Concentration of 2,4-D = 10.08 +/- 0.03 mg/L
***Concentration of 2,4-D remaining after treatment

Research Results - GAC Adsorption

- **Calgon F300 a very common GAC used in home water treatment units was chosen**
- **A bottle point isotherm technique was used with temperature set at 15 ^{o}C for typical groundwater temperatures in a homeowners GAC unit**
- **Freundlich Isotherm parameters were estimated to model the data and predict capacity of the GAC for the 2,4-D**

Research Results – GAC Adsorption Table

Mass of Carbon In Bottle (g/L) (M)	Change in 2,4-D Conc. (mg/L) (ΔC)	Equil. 2,4-D Conc. (mg/L) (Ce)
5.000	9.439	0.638
1.500	4.011	6.066
1.400	3.675	6.402

Research Results – GAC Adsorption Equation

Freundlich Model: $\Delta C/M = K_f C_e^{1/n}$
Linearizing and Solving for the Freundlich Constants we find that:

$$K_f = 2.01;\ 1/n = 0.14$$

For example then if a home GAC unit receives water containing 1 mg/L 2,4-D the capacity for that unit's GAC would be:

$$2.01(1.0)^{0.14} = 2.01 \text{ mg of 2,4-D/g of GAC}$$

If this home used 200 gallons of this water per day then a typical 3 cubic foot unit (about 38 kg of GAC) could theoretically last for about 3 months or one summer season.

Quality Assurance

Standard laboratory Quality Assurance and Quality Control (QA/QC) techniques were used and conform to USEPA and/or Standard Methods for the Analysis of Waters & Wastewater

Specifically control samples, blanks and blind duplicates were used in the analyses and all UV doses were confirmed using techniques approved by the USEPA

All data and QA/QC results were within accepted precision and accuracy levels indicating the experiments were in control the analytical techniques were valid and hence the results were valid and that meaningful conclusions can be drawn from the experiments.

Summary

A preliminary treatment study consisting of 16 samples was conducted to evaluate the treatment of 2, 4-D contaminated wells using UV photolysis; UV-Peroxide advanced oxidation; and GAC adsorption

The preliminary batch, bench-scale results indicate that UV-Peroxide and/or GAC have the potential to cost effectively treat 2, 4-D

Results are preliminary and were performed solely as proof of concept there can be many other site specific factors and considerations that would affect whether or not UV-Peroxide or GAC would be cost effective and practical to use on an actual 2, 4-D contaminated well that is providing water in a flow through semi-continuous manner to a consumer.

The next logical step would be to perform a pilot or field test these preliminary batch bench scale results on an actually flowing well contaminated with 2, 4-D

Appendix D: ACT Final Report

October 12, 2004

Ms. Wendelyn Chapley, Director
NH Division of Pesticide Control
PO Box 2042
Concord, NH 03302-2042

Re: 2004 Milfoil Treatment at Lower Suncook Lake in Barnstead, NH – SP-096

Dear Ms. Chapley:

In accordance with NH Pesticide Rules 603.03, Aquatic Control Technology, Inc. is submitting a written year-end report for the herbicide treatment of Lower Suncook Lake in Barnstead. This treatment was conducted in accordance with the conditions of Special Permit #SP-096, issued by the Division of Pesticide Control.

Treatment Summary

Seven distinct sections of Lower Suncook Lake that totaled 132 acres were treated with Aqua-Kleen (2,4-D granular) - EPA Reg. No. 228-378-4581 on June 25, 2004. The treatment targeted control of nuisance milfoil (*Myriophyllum heterophyllum*). The Suncook Lake Association (SLA) had mapped the milfoil treatment areas during the 2003 season. During a pre-treatment inspection, Aquatic Control inspected the treatment areas and recorded the treatment area locations with a GPS system. SLA then provided GPS coordinates to Aquatic Control. Maps of the lake and the treatment areas were loaded into a Differential GPS system with sub-meter accuracy to provide real-time navigation during the treatment. This system was then used to insure that the herbicide was evenly applied. The GPS trail of the sprayboats was recorded and is depicted in Figure 1A.

A total of 13,200 pounds of Aqua-Kleen herbicide were applied 132 acres that were treated. Due to the quantity of herbicide being applied, Cygnet Enterprises, Aquatic Control's chemical distributor, delivered the herbicide directly to the base of operations located on the northwest shore of the lake. The herbicide was then transferred to pick-up trucks and then into the spray boats. The granular 2,4-D herbicide was evenly applied throughout the treatment areas using calibrated cyclone seeder/spreader mounted on the bow of the sprayboats. The smaller treatment areas were treated using a single Airboat equipped with a cyclone spreader and the DGPS unit. For the larger treatment areas, the Airboat and a conventional sprayboat equipped with cyclone spreaders were used. The Airboat boat would "shadow" the conventional sprayboat that was equipped with the DGPS unit. The use of two boats in tandem significantly shortened the application time, which still required approximately 11 hours, starting at 8:30 a.m. and ending at 7:30 p.m.

Results

The treatment proceeded smoothly and without incident. The post-treatment inspection was conducted on July 15th. By that time, greater than 95% milfoil control was achieved within the treatment areas. No viable milfoil plants were found in the treatment areas or in any other portions of Lower Suncook Lake. Surveys performed by SLA later in the summer did not report any milfoil regrowth.

No adverse impacts to non-targeted plants or other aquatic organisms were observed. Other aquatic plants observed in the treatment areas that appeared to be healthy following treatment included bladderwort, largeleaf pondweed, wild celery, white waterlilies and stonewort. The 2,4-D application achieved highly selective control of milfoil, while preserving most of the desirable native plants in the lake.

The post treatment herbicide residue samples required under SP-096 were collected by Victor Piekarski and were delivered to ChemServe Laboratories in Milford, NH for analysis in accordance with the permit conditions. Copies of the laboratory results were previously provided to your office under a separate cover. Part of the research project with UNH also called for SLA to collect several additional herbicide residue tests following the treatment from multiple locations within the lake, downstream and from some adjacent shallow wells. Results of all of the in-lake testing were similar, with concentrations dropping below the drinking water threshold of 70 ppb approximately three weeks after the treatment date. SLA also reported that no herbicide residues were detected at any time in the shallow wells that were tested.

2,4-D herbicide typically provides one to three years of effective milfoil control. While non-chemical techniques will be considered and employed where feasible, continuation of a maintenance treatment program may be required during the 2006 or 2007 season, based on the duration of milfoil control achieved at other lakes in New Hampshire that were previously treated with 2,4-D.

Please feel free to contact our office if you have any questions or require additional information.

Sincerely,
AQUATIC CONTROL TECHNOLOGY, INC.

Marc Bellaud
Senior Biologist

cc: Ed Neister, Suncook Lake Association